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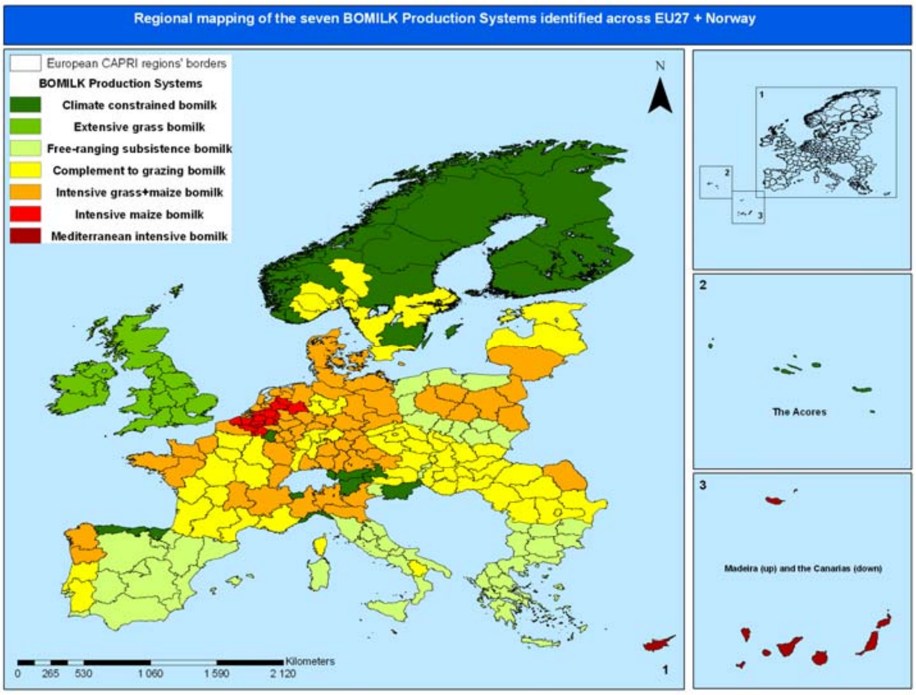
The GGELS project:

European Greenhouse Gases Emissions from Livestock Production Systems

LPS Regional zoning for the survey of related manure management practices



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Evaluation of the EU livestock sectors' contribution to the greenhouse gas emission – Phase 1 (GGELS)

Administrative Arrangement (AA) No. AGRI-2008-0245

GGELS

European Greenhouse Gases Emissions from Livestock Production Systems

LPS Regional zoning for the survey of the related manure management practices

Contents

1. Introduction

According to the Administrative Arrangement (AA) No. AGRI-2008-0245[1] signed between DG AGRI and DG JRC, Work Package 2 (WP2) of the GGELS project has to focus on the "Conceptualisation and Build up of Livestock Typology"[2]. The main task of WP2 is the establishment of a LPS typology at NUTS2 level covering all EU27. This LPS typology should allow European regions to be differentiated according to the diversity of LPS farming such as herds' assemblage, feeding strategies or again manures management practices which condition GreenHouse Gazes emissions (GHG) from livestock sectors. Concerning manures management practices, since no specific information exists at region level, while JRC expertise on this issue is insufficient, it has been decided to launch a call for tender[3] to select academic parties for a specific study on this issue following a questionnaire approach. The results of this survey should improve NUTS II LPS description with manure management information for each such region-LPS combination and improve efficiency of the final LPS typology to be produced.

As indicated inside the related technical specifications, study on "Regional manure management practices in EU27" should target European regions according to their LPS characteristics such as, first, animal species. For that, LPS characteristics should be identified previously to the survey by JRC and provided to the contractor to perform GHG EF and manure management sampling and assure relevance of the results obtained from the questionnaires to be addressed to national experts. Annex 1 of the study listed a number of dimensions to be considered to represent regional diversity of LPS; these main dimensions have been carefully considered to represent European LPS diversity:

- <u>subnational regions concerned</u> i.e. LPS characteristics should be detailed at subnational scale
- <u>climatic zone</u> i.e. agroecologic zoning of the main climates met in Europe should be provided
- <u>average farm size</u> i.e. description of the farm types and level of specialisation
- <u>productivity</u> i.e. elements describing production strategies to productivity should be considered.

From that, JRC has decided to build its regional zoning of LPS diversity from one major complete and consistent database grouping national economic accountancy of agriculture and regional characteristics of livestock production activities in Europe i.e. the CAPRI[4] Coco database (Britz & Witzke, 2008). Further, CAPRI being the system from which European GHG emissions would be modelled and political scenarios tested, it appeared pertinent to have recourse to its datasets.

Consequently, this document is describing the methodology and the results of the subnational zoning of European LPS as expected to be provided to the contractor in charge of the "EU27 regional survey of the manure management practices" study.

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[1] Administrative Arrangement (AA) JRC Contract n° 30944-2008-04 NFP ISP N° AGRI-2008-0245 between DG Agriculture and Rural Development (DG AGRI) and the Joint Research Centre (JRC)
[2] AA n° 30944-2008-04 NFP ISP N° AGRI-2008-0245: WP2: Typology and characterization of the EU livestock sector – Task 2.1: Conceptualisation – point N°4: Manure management
[3] Tender specifications: Qualitative assessment of manure management in main livestock production systems and a review of gaseous emissions factors of manure throughout EU27 (specs_16884.doc)
4 CAPRI: Common Agricultural Policy Regional Impact Analysis (see http://www.ilr1.uni-bonn.de/agpo/rsrch/capri/capri_e.htm)

In the first part, the necessary aspects of LPS to be taken into account for zoning European LPS diversity would be largely pointed out. In a second part, by considering information availability inside CAPRI databases, a restricted list of regional LPS characteristics would be proposed. Then, the methodologies used to produce LPS indicators and to perform European regions classification are described in the third part. The fourth part is dedicated to the presentation of the zoning results obtained for each one of the LPS components retained; this asking for a large mapping effort through Geographic Information System (GIS) environment. Finally, in the last part, lists of European regions to be sampled when addressing region-LPS combination are proposed and discussed.

2. LPS characteristics towards manure management strategies

The aim of the European LPS zoning being to facilitate the setting up of a survey to elicit "Manure management practices in Europe", a primary description of manure production and management is to be undertaken.

As pointed out by Burton & Turner (2003), animal production in Europe has considerably changes in the last decades with e trend towards more specialized and intensive production systems. The increase of the size of the holding is generally accompanied by a reduction of the labour forces per hectare of crop or per livestock head, leading to the increased use of machinery, plant production products and processed animal feedstuffs and to a higher specialization of the LPS. In the same time, the increase of the meat demand (+ 4% between 1996 and 1999 – Aumaître, 2001) and the reduction of the purchasing capacities of consumers ask for the intensification of the livestock production practices and the reduction of the associated costs.

If intensification and specialization of the LPS is the trend in Europe, not all the holdings have followed or have had the possibility to follow it. Livestock farming systems are varying from one country to another, or even, from one region to another in the same country depending on intrinsic climatic, land use or cultural characteristics of the regions. To date, this is conducing to a large range of LPS in Europe.

LPS diversity is described by a range of farming characteristics among them (i) animal species and numbers, (ii) targeted production sector i.e. specialisation, (iii) intensification of livestock production and (iv) manure management strategy coupled to cropping system are perceived as priorities when classifying LPS (Burton & Turner, 2003).

2.1. Animal species and numbers

When considering livestock production, animal numbers can be easily undertaken at any level of the work. Regional production of bovine meat or milk in a region is for instance a good indicator of the number of respectively cattle for milk and cattle for meat which can be found in a region. Simultaneously, manure production is also strongly correlated to the herd size in a region. Consequently, there are different possibilities to address animal numbers. However, the sole consideration of the herd size is not informative enough; it just allow regions to be classed by considering abundance of animal heads (per animal species) or of livestock units[5] (when no distinction is made between animal species) and for depicting of regional livestock production concentration. At the opposite, animal species asks for the stratification of total regional herd in

[5] Where one livestock unit – LU – is defined as the environmental impact of a 500 kg dairy cow

species-related herds. Then, absolute abundance[6] or relative abundance[7] can be used to describe the herd size of one given animal species.

Whatever the choice made to express animal number in absolute or relative values, and to consider total or species herd size, the result is just a density of production by animal species at regional level.

To obtain a higher level of pertinence, livestock number is often used together with cropping system information, or with feeding strategies to provide more precise information onto the level of intensification and specialization of the LPS. For instance, intensification can be expressed as the number of grazing livestock units per hectare of fodder area i.e. the stocking density. By representing the capacities of a local cropping system to absorb nitrogen (phosphorus and potassium as well) from manures, high stocking densities[8] give then a precise idea of the potential environmental risk that livestock production is exerting over biodiversity (Mayer et al., 2005), nitrate pollution of water resources (Ridley et al., 1999; de Klein & Ledgart, 2001; Anger et al., 2002) and GHG emission (Soussana, 2004). If too small[9], stocking density also describes situation where under utilisation of pastures could conduct to woody encroachments and a sharp decrease of the potential of biomass production (Zarovali et al., 2007). On the other hand, crops or pasture production can be divided by the number of animals to express the potential energy and protein autonomy of a LPS or a specific holding (Kainea & Tozer, 2005).

On the other hand, distinction between animal species is very important to be considered when addressing manure production and management. In effect, nature of manure to be managed is partly dependent of the animal species present in a region. Three broad categories of manure are generally considered (Burton & Turner, 2003):

- Liquid manure or slurry are produced by animals generally raise indoor on solid floors regularly swept clear of any excreta by using wash water – it represents an important proportion of holding producing pig meat. In 1996, slatted floors represented 75 and 78% of floors used in buildings for finishing pigs respectively for Denmark and France (Aumaître, 1996).
- Solid manure from animals kept on bedding material which is collected together with all excreta as farm yard manure (FAM) – many dairy cattle in France, Scandinavian and Eastern Europe countries have recourse to bedding material and are collecting solid.
- Mixed manure when animals kept on bedding material but liquids are drained from the bedding and collected elsewhere.

However, animal species is not enough alone to decide of the nature of manure produced in a region and of the manure management strategies. Other information such as the proportion of time a year spent indoor (from 100% for housed raising cattle fed with fodders and import of feedstuffs on farm to few percent in case of sufficient grazing pastures available on farm) or the pasture management (grazing or haymaking pasture) are necessary.

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[6] Absolute abundance (n) as the exact number of individuals in a given herd

[7] Relative abundance (n/N in %) as the proportion of individuals in a herd (n, cattle milk for instance) over the total number of bovine individuals in a region (N, cattle milk + cattle meat)

[8] Rule of thumb is to consider stocking density > 1.4 LU/ha of fodder area as intensive and at risk for water nitrate pollution (Ernst and Young, 2007)

[9] Rule of thumb is to consider stocking density < 0.8 LU/ha of fodder area as very extensive and at risk for woody encroachments

2.2. Specialization

Considering animals or livestock unit numbers also allows for depicting the concentration of certain livestock production in definite regions. Regional specialization is generally due to the concentration of all livestock sector facilities such as feedstuffs manufacturing, slaughtering plants, processing plants and marketing industries in one or few single regions a country. This could have been encouraged by local authorities and/or governments as a way to accelerate and make perennial a certain livestock sector. However, other reasons can explain the development of such regions of concentrated activity: the geographical (proximity to transport networks and market places), environmental (climatic, crop potential) or cultural advantages can separately or all together decide of the concentration of livestock production and of the specialization of a region. Reciprocally, specialization also concerns every one of the producers present in the region. When he's not a pioneer but only a follower, the farmer would largely benefit from the local sector advantages if he decides to adapt his farming to the regional specialized production and to adopt the related practices. It provides him a more constant market opportunity over time. On the other hand, specialization conducts to high investment efforts for adapted machinery and buildings and selective cropping system; this reduces the flexibility and the capacity of the holding to adapt its production in case of agricultural sector crisis.

Specialization is generally determined from the proportion of the revenues/incomes coming from each one of the production activities present in the holding; the larger source(s) of income is (are) then describing of the specialization adopted by the holding. Based on the standard growth margin (SGM), European statistical surveys such as FADN[10] is attributing type to the holdings according to the first or the two-first main sources of revenues met. Specialized "granivores (type 50)" in FADN are presenting a higher income share from pigs and/or poultry production and are dispatched into three different second order types (501- specialist pigs, 502 - specialist poultry and 503 – various granivores); once again, each one can be dispatched into several third-order types (5011 – specialist pig rearing, 5012 – specialist pig fattening…).

If specialization in a region generally matches the farms specialization (Jutland in Denmark, Brittany in France or again Catalunya in Spain are presenting very specialized farms matching the regional specialization), this trend is not always valid. Relationship between regional specialization and farms specialization has to be considered carefully. Attention must be paid to not consider the sole regional output to determine specialization. If only few specialized holdings are concentrating a very large proportion of the regional herd size, the rest of the holdings, whatever the specialization, would have limited influence onto the output-based regional specialization. This, even if they are counting for the larger used arable area and are essential to be considered when addressing landscape management and biodiversity conservation.

Consequently, attribution of a level of specialization to a region should focus onto major sources of incomes as well as to farm types' assemblages in a region. This is especially true when considering indoor livestock productions (granivores, very intensive dairy cattle…) which require very little dedicated land area, ask for large and efficient manure management systems and involve supplementary agricultural areas to land-spread manures.

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[10] FADN: The Farm Accountancy Data Network from DG AGRI is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy http://ec.europa.eu/agriculture/rica/index_en.cfm

2.3. Livestock production intensification

Intensification can be expressed in different manners. Intensification is for instance expressed as the quantity of product obtain from one animal i.e. the yield or as the total output in Euro per ha (Andersen et al., 2006). It can be also expressed as the number of grazing animal per ha of fodder area (see § 2.1.) and very often as the level of inputs (standardized economic valuation) used per animal (or livestock unit) or per unit of product.

In the same time, independently of the animal species/race considered, manure composition is strongly dependent of livestock production techniques such as feeding strategy, animal housing or again storage and land-spreading systems used. Feeding strategy impacts on manure production has been largely described (Driedger & Loerch, 1999; Kerr et al., 2006; Hoffman et al., 2007). Limit-fed diets tend to significantly reduce the quantity of manure produced (bulk density and dry matter) or the composition of excreta (NH4 in slurry and headspace N2O). At the opposite, rich protein diets have for consequences a high concentration of nitrogen and phosphorus in excreta corresponding in such situations to protein feed luxury consumption (Tomlinson et al., 1996; Portejoie et al., 2004; Philippe et al., 2006). Trends from dairy cattle are also observed for finishing pigs when considering the sole lysine in the crude protein fraction of feedstuffs (Salter et al., 1990).

Thus, the later paragraph highlights the fact that feeding strategy has to be considered when determining the level of intensification of livestock production in a region. But the fact that farmers are using merchantable concentrated feedstuffs together with homemade feedstuffs makes the determination of the intensification level difficult. Information concerning the share of auto-consumed and purchases feedstuffs is often too limited or even unavailable. The precise determination of the level of intensification from the feeding strategy is then rough. However, together with the proportion of the investments dedicated to the animal diet and/or the veterinary protection, potential autonomy to feed (energy, protein, lysine…) animals could allow the regional level of intensification for a given production to be estimated.

2.4. Manure management strategy

If land application is the most widespread disposal technique for manures, many different manure storages are used in Europe. Vessel storage for liquid manure and slurry, concrete pads for solid manure from which effluent draining out are collecting separately or again weeping wall stores for wetter manure, and deep-litter storage in animal house before spreading are examples of provisions for storage. Storage is generally decided according to the type of manure, the storage capacity needed and the regulatory restrictions in vigour. As mentioned previously, to date, no complete and precise information concerning manure management strategies adopted over Europe is available. If MATRESA[11] project and RAMIRAN[12] survey described general trend and techniques, the information was often incomplete to provide a clear description of the manure management solutions in use in every one of the EU27 regions together with local livestock production specificities and agro-ecological conditions. Then, a complete and relevant typology of the LPS not including the manure management strategies in use was out of order. Consequently, in the frame of the GGELS project, it has been decided to obtain the missing information by surveying every one of the regions in Europe (EU27) which present particular but representative LPS characteristics.

This task being outsourced, it was important to provide to the contractor, a clear and as complete as possible description of the LPS existing in Europe. In accordance with the previous paragraphs, regional animals assemblages, livestock production specialization and intensification have been

[11] MATRESA: MAnure TREatment Strategies for Sustainable Agriculture (see Burton & Turner, 2003)
[12] RAMIRAN: Research Network on Recycling of Agricultural and Industrial Residues in Agriculture (http://www.ramiran.net/)

taken into consideration. We also described related cropping systems in use in a region. To date, no well organised manures market exists; and manures transportation was considered as very limited: as in CAPRI Modelling System, we assumed that manures are used locally to fertilize crops present on-farm or in the neighbouring (in the region). This allowed us to consider each one of the European region independently and to calculate individual nitrogen-N balance (the same for phosphorus-P and potassium-K) and potential N-surplus as an indication of the environmental risk LPS is exerting over a region (for details, see Peres-Dominges, 2005).

3. CAPRI Modelling System and data availability

Regarding the range of modelling systems available to date, and considering that the central expectation of the GGELS project is the GHG emissions quantification of LPS activities in Europe, we decided to adopt the CAPRI (Common Agricultural Policy Regional Impact analysis) modelling system as main instrument of analysis[13]. CAPRI is connecting GHG emissions calculation from robust European statistical data; and it gives the possibility to simulate GHG emissions of Agriculture (or one given agricultural activity) according to CAP scenarios to be tested.

CAPRI system was designed from the beginning as a complex projection and simulation tool for the agricultural sector based on (Perez Dominguez, 2005):

- an activity breakdown of regional agricultural production (about 50 activities) and farm and market balances (60 products, 30 inputs);
- a physical consistency framework covering balances for agricultural area, animals, animal feedstuffs and crops nutrients requirements (as constraints in the regional supply model);
- economic accounting principles (from EAA) from which all inputs and outputs declared inside national agricultural accounting systems are considered and revenues and costs are broken down by region and production activity;
- a detailed policy description for which all relevant agriculture payment schemes are integrated inside the regional supply models together with non-EU policy and word market components;
- behavioural functions and allocation mechanisms in line with micro-economy theory.

From this, general CAPRI structure is organized around two main model components: the market and the supply modules (Figure 1 - to be updated to EU27).

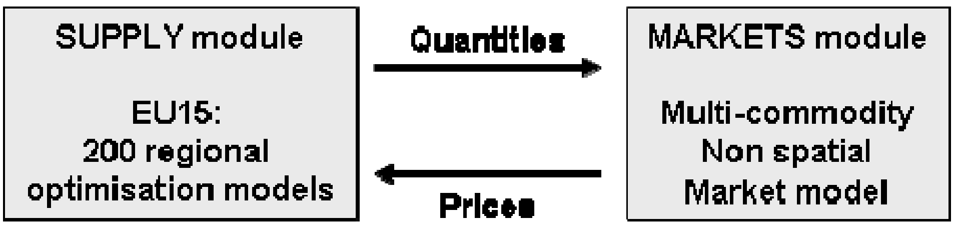

Figure 1: General CAPRI model layout

Basically, CAPRI modules are informed with a set of European statistics datasets such as NewChronos, SPEL, etc. which provide information at national level and are made consistent inside CAPRI CoCo database; statistical data are then regionalized when confronted under constraints to the REGIO database (Figure 2).

[13] http://en.wikipedia.org/wiki/CAPRI_model

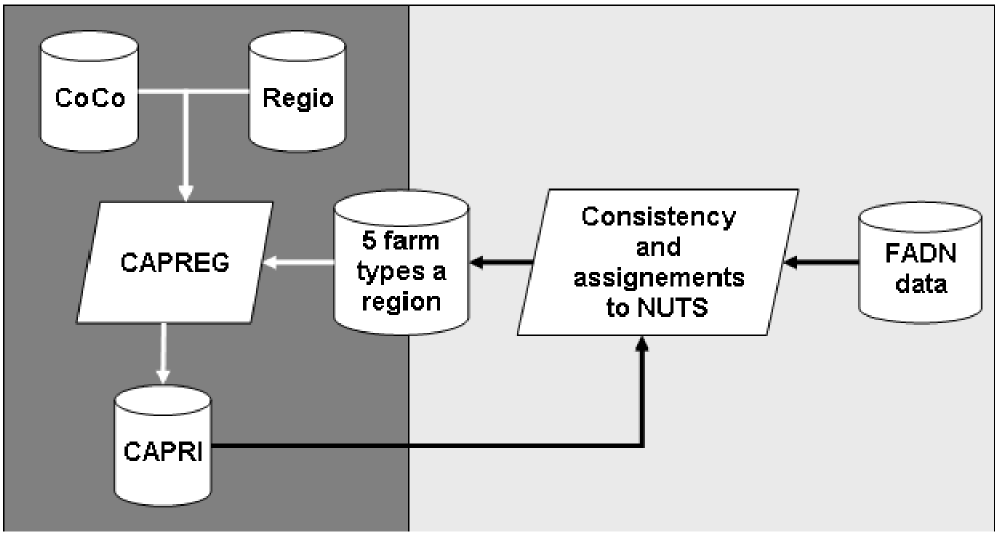

Figure 2: General interconnection between CAPRI databases and FADN based-on farm typology in the frame of the SEAMLESS project

Amongst the different modules, some are more linked with the problematic addressed in GGELS project – the FEEDING and FERTILIZING modules in which all input/output livestock-related activities and practices are considered and GHG emissions quantified – the FARM TYPE module which is mainly dedicated to interpretation and communication by connecting results from simulation to main agricultural activities identified in a region – the DNDC module generating environmental indicators of sustainability for the different agricultural activities identified in a region and finally the DAOUT module for mapping/zoning and communication purposes (Britz and Witzke, 2008). Concerning the FARM TYPE module, farm types as defined in FADN are not conserved inside CAPRI. In fact, in CAPRI, farms are classified according to 50 possible agricultural activities. Later, only the five main representative activities in a region are considered; remaining farms not distributed in the formers are summed inside a sixth activity group so called "rest". This allows for lightening simulation time costs and to not provide overloaded and difficult to interpret results.

Unfortunately, databases used within CAPRI (national databases = Eurostat - area statistics, farm and market balances, Economic Accounts for Agriculture, agricultural prices … regional databases = REGIO and data on Common Agriculture Policy from DG-AGRI - engineering information as animal requirements, regionalised data including fertilizer and feed distribution …) and compiled inside CAPRI CAPREG database do not provide all the information necessary to describe precisely the manures management strategies in vigour at regional level. However, from this, it's possible to depict main regional characteristics and trends of LPS. We used 2002 CAPRI baseline as source of data to describe LPS. All the variables grabbed or calculated from 2002 CAPRI baseline have been grouped inside *"GGELS_final_table.xls"* to further uses; details concerning the variables are given in annex 1. All these explicative variables have been used to process stratification-classification of the European regions according to the LPS descriptors retained.

4. LPS descriptors

The descriptors used to class the regional LPS are obtained or calculated from 2002 CAPRI baseline dataset. It concerns every one of the 243 regions (see annex 2) that CAPRI is considering in EU27 + Norway. These descriptors concern the six different livestock production sectors retained in this study:

- BOMILK as dairy cattle for milk production
- BOMEAT as meat production from bovine livestock
- POUFAT as the meat production from poultry (broilers…)
- LAHENS as the eggs production from hens
- SHGOAT as the meat and milk production from sheep's and goats (ewes…)
- PORCIN as the pig activity concerning the meat and the rearing (sows) activities.

The different descriptors retained can be grouped into 10 different categories:

- Identifiers (to identify regional and/or national level – used in GIS to communicate mapped results)
- Animal assemblages and livestock herd diversity to characterize regions according to the assemblages observed of the six different livestock sectors considered in this study (BOMILK, BOMEAT, POUFAT, LAHENS, SHGOAT, PORCIN)
- Climate data allowing regional agro-ecological situation to be described
- Intensification has been expressed in different ways: (i) as the total costs (€) and the proportion (%) over the total cost of production of money dedicated to feedstuffs and veterinary products and (ii) as the stocking density (for grazing livestock)
- Production being largely available from CAPRI we used total revenue per livestock sector in a region, revenue per head or per livestock unit, or again percentage of the total livestock revenue coming from one specific livestock sector (revenues from crops were also used)
- Farm types: to verify classification of regions from animals assemblages we decided to confront our results to the Eurostat data at regional level. Farm types which have been considered were those addressing fully or partly livestock production.
- Cropping system is described as the true area or the proportion of the total regional agricultural area used to grow one specific crop (sunflower for instance) or a family of crops (cereals for instance)
- Manure production: no information concerning the storage and spreading systems in use in region, we focused onto the quantity of manures (total or N, P, K) produced by livestock sector.
- Feeding strategy: apart from the money spent for feedstuffs purchasing which is available in CAPRI, feeding strategy cannot be directly calculated because of the lack of knowledge considering on-farm auto-consumption of crop's products. In this special case, we calculated the proportion of grazing animal energy and protein annual requirements which could be covered by the use of the sole fodder crops – it conducted to the obtaining of a fodders-energy and -protein autonomy of the regions. For granivores (PORCIN, LAHENS and POUFAT) the regional lysine autosufficiency was calculated as the balance between the "rich protein crops (rape, soybean, sunflower) + wheat and barley" supplies and the annual granivores lysine requirements. It was expressed as a percentage of the total requirements.
- Environmental impact: as an output of the CAPRI-dynaspat simulation platform, total N-P-K from manures was confronted to total N-P-K plants' requirements to determine the potential utilization which could be done of the manure to fulfil plants requirements (N-P-

K) i.e. regional N-P-K autonomy and the risk of N-P-K surplus in a region; the latter being considered as an indicator of the risk of ground- and surface-water pollution by nitrate and phosphate from livestock activities.

Among all the dimensions presented below, specialization is not clearly visible. In fact, we considered specialization as the result of considering both the cropping and the livestock production systems. Indeed, according to us, only cross-comparison of information describing the cropping system and information eliciting animals assemblage should allow us to define the nature and the level of specialization of a given region. This step is discussed within the sixth paragraph of this document.

4.1. LPS descriptors directly extracted from 2002 CAPRI baseline

To data traditionally available inside CAPRI, simple calculation of secondary variables have been undertaken to limit the effect of correlation between raw data. For instance, production expressed as a total quantity of product or as a total amount of money was very strongly correlated with the size of the herds within a region. By calculating relative values (%), particularities of each region were safeguarded and correlation avoided; this allowed the simultaneous use of information of the same nature without risk of overweighting of these variables.

However, in certain circumstances, information provided by CAPRI was not sufficient and additional estimation was necessary.

4.2. Additional and calculated descriptors

Complementary data concerning climate – feeding strategy – and farm type have been obtained from JRC Agri4cast action, INRAtion © and Eurostat respectively. Diversity of the animals assemblages in EU27 + Norway was also processed by having recourse to ecological methodologies. The methods used are briefly presented hereinafter.

4.2.1. Climate

Climatic data were extracted and processed from the current Crop Growth Monitoring System (CGMS) version 2.3 managed by JRC Agri4cast action. Complete description of the CMGS is use in JRC can be found in “The MARS Crop Yield Forecasting System” (Micale & Genovese, 2005).

Climatic data are provided through a network of 6000 meteorological stations in Europe and neighbouring countries (Figure 3). These data are generally used as input for crop growth model and as weather indicators for a direct evaluation of alarming climatic situations. The data are collected from various sources including METAR[14]. Observations of maximum and minimum temperatures, precipitation and sunshine duration are daily processed; METAR also provides temperature, dew point, visibility and cloud amount. Other meteorological information are provided such as potential evapotranspiration, climatic water balance, global radiation or again snow depth.

[14] METAR: METeorological Airport Report

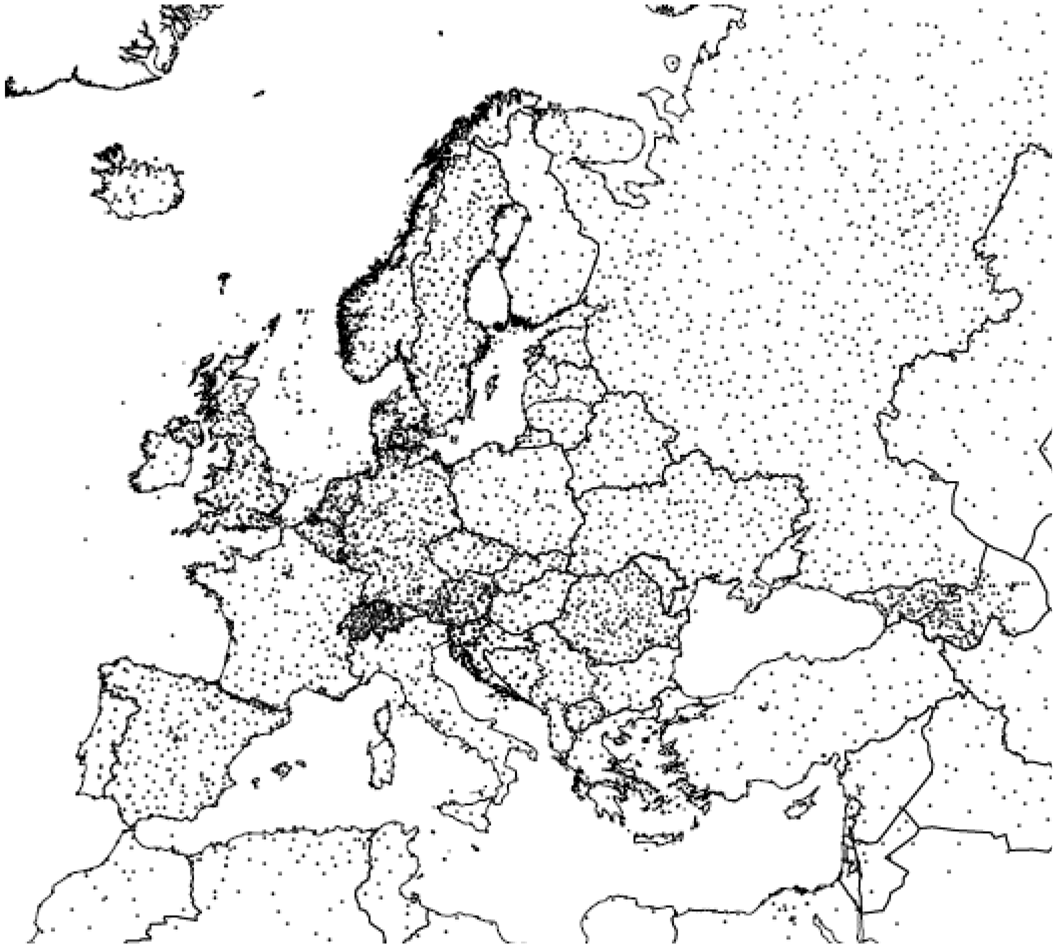

Figure 3: Network of meteorological stations for which data is available for (part of) the period from 1975 until the current day (Micale & Genovese, 2005)

After data quality check, daily meteorological data are interpolating onto a regular climatic grid of 50 by 50 kilometres. From this grid, averaged values of climatic data are obtained by aggregating cells of the grid linked to a given region; aggregation is made by weighting each cell used according to the proportion of the cell area contained within the region.

For the purpose of the GGELS project, a limited list of meteorological variables has been decided. These variables have been chosen to point out the climatic potential of a region for crop growth and animal welfare: cumulative sum of temperature ($°C.day^{-1}$, base temperature of 0°C), temperature (°C), precipitation (mm), photosynthetic active radiation ($MJ.m^{-2}.day^{-1}$) and number of rainy, snowy, frozen days. Some of them have been calculated as cumulative sum for the first 3, 6 and 12 months of the year (to proximate growing period duration and/or to match cropping system calendar).

For each one of the region, elevation characteristics were obtained from SRTM 90v4 (void filled) by joining elevation data with regional NUTS2 delineation inside GIS. Average and standard deviation were obtained for each one of the 243 regions considered inside CAPRI. Dispersion index calculated as the variance-to-mean ratio was used as complementary information describing the level of uniformity of the elevation within a region. Equation is presented below.

$$D_I = \frac{\sigma^2}{\mu} \qquad \text{(equation 1)}$$

4.2.2. *Animals assemblages*

To describe the animals assemblages and in the same time to point out of the specialization over Europe, we had recourse to an ecological method based on the calculation of the index of similarity between two herds situated in two distinct European regions. Similarity index was calculated for each one of the possible pairs of regions. Data used should allow us to weight each one of the six livestock sectors considered according to its participation to GHG emission; consequently, we used "abundance" expressed as the number of livestock units (LU) in a region. Because statistical processes request non zero and missing values, raw abundance *Ai,r* for a livestock sector *i* in a region *j* was square rooted after addition of 1 LU. This also allowed us to not overweight highly represented livestock sectors against rare/absent livestock sectors in a region and to process multivariate methods related to population similarity estimation (Cheng, 2004).

There are numerous measurements of similarity (Legendre and Legendre, 1983), and confusion exists about which similarity measurement to use. Two broad classes of similarity coefficient exist: (i) binary coefficients using presence/absence (1/0) data, such as Jaccard's coefficient (Chao, 2005) or Sorensen's coefficient (Sorensen, 1948); these coefficients are generally used when only the lists of species are available and comparisons are possible at this lower level of resolution, weighting rare species the same as common species; (ii) quantitative coefficients for which supplementary information such as species abundance in an assemblage is required; among these, Morisita's index of similarity (Morisita, 1959) is considered the best overall measurement of similarity for ecological use (Wolda, 1981), almost independent of sample size (unlike Sorensen's index).

Morisita's similarity coefficient for each pair of regional animals assemblages (transformed data) was calculated as follows:

$$C_\lambda = \frac{2\sum (X_{ij} X_{ik})}{\left((\lambda_1 + \lambda_2) n_j n_k\right)} \qquad \text{(equation 2)}$$

where:

$$\lambda_1 = \frac{\sum (X_{ij}(X_{ij} - 1))}{\left(n_j (n_j - 1)\right)} \qquad \text{(equation 3)}$$

$$\lambda_2 = \frac{\sum (X_{ik}(X_{ik} - 1))}{\left(n_k (n_k - 1)\right)} \qquad \text{(equation 4)}$$

where C_λ = Morisita's index of similarity between regions j and k,

X_{ij}, X_{ik} = the number of livestock units of the livestock sector i in regions j and k,

n_i, n_k = the total numbers of livestock units in regions j and k.

The principal advantage of this similarity index is that it considers together the number of species present in an assemblage and the magnitude of the total and species-related abundances.

Method used when estimating similarity between species' assemblages (here, livestock sectors or animals assemblages) is ordination. Ordination entails multivariate methods; different multivariate methods exist, such as hierarchical clustering (Johnson and Wichern, 1992), non-metric multidimensional scaling (NMDS) (Kruskal, 1964), correspondence analysis (CA) (Jongmann et al., 1995) or principal component analysis (PCA). They start from a triangular matrix of similarity indices between every pair of animals assemblages (of regions). All the methods are applied to reduce the complexity of multivariate information in the original matrices to a low-dimensional picture.

We chose to apply two multivariate methods: (i) PCA processed into JMP-V6.0 platform (The SAS Institute)[15] after obtaining of the double matrix of Morisita's index of similarity from EstimateS V8.0[16] (Colwell, 2004) and (ii) NMDS processed directly with transformed value of abundance through PAST software[17]. The coordinates of every one of the regions on the significant (>80%) PCA principal components and NMDS axis were added to the GGELS_final_table.xls.

4.2.3. Feeding strategy

Despite the fact that data concerning animal energy, protein and lysine (for granivores only) requirements per animal are directly available inside 2002 CAPRI baseline database, the lack of explanation concerning the units used and the necessity to update feeding factors asked for a complete recalculation of the animals requirements. This was undertaken for each one of the eighteen livestock production activities considered inside CAPRI (DCOH, DCOL… see annex 1); then requirements were calculated per herd and grouped to obtain total energy/protein/lysine requirements for each one of the six livestock sectors considered in GGELS.

The method and main characteristics describing animal production and growth considered within CAPRI (Nasuelli et al., 1997) was respected. However, certain values were extracted from current literature (mainly for granivores) and from "Alimentation des bovines, ovins et caprins" (INRA, 2007) for grazing livestock. The approach being relatively similar between livestock activities considered inside CAPRI, we briefly detailed hereinafter the method used for two categories: dairy cow (CAMILK) and poultry for fattening (POUFAT).

- Dairy cow (CAMILK):

  The requirements (energy as well as protein) for a dairy cow correspond to the sum of the requirements for (i) the maintenance, (ii) the milk production and (iii) the gestation.

  Accordingly to INRA procedure (INRA, 2007), a dairy cow was assumed to be 40 months old – of medium corporal status – with a live weight of 650 kg – inseminated at 13th week. Simulation of milk production corresponded to the 25th week (mid-term). Complementary information such as regional CAMILK production of milk ($l.head^{-1}.year^{-1}$) was extracted from CAPRI database. Milk production duration was considered as equal to 305 days. 2002 values of the protein and fat content of milk were extracted from Eurostat database.

  - Maintenance (M) requirements:

$$R_M = \left[\left(0.041 * LW^{0.75} \right) * I_{act} \right] \qquad \text{(equation 5)}$$

  Where

  R_M, the maintenance energy requirements per day

  LW, the live weight (650kg)

  I_{act}, the index of activity of the animal corresponding to a supplementary maintenance requirements for animal reared indoor (I_{act}=1), outdoor (I_{act} = 1.2) or mixed (I_{act}= 1.1). I_{act} was regionally determined according to the assumption that

[15] http://www.jmp.com/software/

[16] http://viceroy.eeb.uconn.edu/EstimateSPages/AboutEstimateS.htm

[17] http://folk.uio.no/ohammer/past/index.html

regional stocking density of grazing animals >2 conducts to indoor rearing, <2 but ≥1 conducts to mixed rearing, and <1 to outdoor rearing.

- Milk Production (MP) requirements:

$$R_{MP} = \left[MP_{avg} * \left[0.44 + \left(0.0055 * \left(C_F - 40\right)\right) + \left(0.0033 * \left(C_P - 31\right)\right)\right]\right] \quad \text{(equation 6)}$$

Where

R_{MP}, the milk production energy requirements per day

C_F, the regional fat content of milk

C_P, the regional protein content of milk

MP_{avg}, the daily milk production per dairy cow calculated from the annual milk production per dairy cow given in CAPRI ($MP_{CAPRI/year}$) divided by 305 days of production a year

$MP_{CAPRI/year}$ corresponds to the annual production of a dairy cow in a given region

- Gestation (G) requirements:

$$R_G = \left[0.00072 * \left(VW_{birth} * e^{(0.116*IW)}\right)\right] \quad \text{(equation 7)}$$

Where

R_G, the gestation energy requirements per day

VW_{birth}, the veal weight at birth, considered as equal to 45 kg

IW, the insemination week, considered as equal to the mean value observed, 13th week

Then over the year, the total energy requirements for dairy cow is equal to the daily requirements for maintenance, milk production and gestation multiplied respectively by the number of days for each activity: 365 days of maintenance, 305 days of milk production and 270 days of gestation (CAPRI values). Values obtained are expressed in French UFL (Unité fourrage vache laitière) and were converted into MJ/head^{-1}.year^{-1} (by multiplying by 1700 to obtained Kcal then by 4.185 to obtain kJ).

In the same manner, protein requirements per dairy cow a day are calculated by summing maintenance, milk production and gestation protein requirements weighted by the specific number of days of each one of these the three activities:

$$R_{Prot} = \left[\left(3.25 * LW^{0.75}\right) + \left(1.56 * LW * CP\right) + \left(0.07 * VW_{birth} * e^{0.111*IW}\right)\right] \quad \text{(equation 8)}$$

- Poultry for fattening (POUFAT):

Concerning granivores activities, it has been initially decided to class European regions according to the level of digestible lysine autosufficiency of the regions defined as the percentage of the digestible lysine requirements covered by the lysine coming from rich protein crops + wheat and barley production a region. Thus, digestible lysine requirements for each one of the three granivores sectors (LAHENS, POUFAT and PORCIN) have been calculated. Example of poultry for fattening (POUFAT) is provided below.

From total production of carcass from poultry (in tons) and number of heads provided by CAPRI, we calculated the mean carcass weight of broilers (kg) in a region from which a mean live weight (LW_f) per individual was obtained by divided the carcass weight by 0.75 (Brake et al., 1995). From this, maintenance and growth energy requirements were calculated for the birth-to-8 weeks old period of growth of broilers following Leclercq & Beaumont (2000):

Then the mean metabolic size of the broiler (T) was calculating as follows:

$$T = \left[LW^{0.75}\right] \qquad \text{(equation 9)}$$

The averaged weight (LW_{avg}) of a broiler over the growth period (60 days, default value) is calculated from the initial weight (LW_i= 30g) to which is added half of the final live weight (LW_f)

$$LW_{avg} = LW_i + \left(\frac{LW_f - LW_i}{2}\right) \qquad \text{(equation 10)}$$

The lipid content of meat (C_{Lip}) is considered as equal to 0.17 g/g from which protein content of meat (C_P) is calculated as follows:

$$C_P = 0.225 - (0.27 * C_{Lip}) \qquad \text{(equation 11)}$$

Maintenance (R_M) and growth (R_G) energy requirements are given by the following formula:

$$R_M = 130 * T * EE * 20 \qquad \text{(equation 12)}$$

$$R_G = \left(LW_f - LW_i\right) * \left[\left(9.47 * C_P\right) + \left(10.47 * C_{Lip}\right)\right] \qquad \text{(equation 13)}$$

Where

EE, the energy efficiency being considered as equal to 1 (0.9 for laying hens)

From this, quantity of aliment to be consumed during the life of one broiler (C, kg) is calculated as follows:

$$C = \left(R_M + R_G\right)/3200 \qquad \text{(equation 14)}$$

And finally, the quantity of digestible lysine necessary per broiler along life being equal to 8.56 g per kilogram of aliment consumed (Leclercq & Beaumont, 2000), total amount of digestible lysine needed a year was calculated by multiplying the individual broiler requirement by the number of heads produced in one given region.

- Grazing livestock energy & protein autonomy and granivores digestible lysine autosufficiency:

To obtain regional energy/protein autonomy and digestible lysine autosufficiency indicators, requirements calculated as shown above, were directly compared to the regional energy/protein supplies from fodder activities (for grazing livestock) and lysine supplies from rich protein crops + main cereals directly usable for granivores (wheat, barley, grain maize). Proportion (%) of local requirements covered by local supplies inside a region corresponded to expected autonomy and autosufficiency proxies. For that, land use share (hectare) and production share in a region are necessary.

Inside CAPRI, the EUROSTAT's REGIO data on regionalized agricultural data in the EU is used; then, data available inside REGIO are made consistent with the sectoral SPEL-EU data base as a frame for any regionalization. The SPEL-EU data base is an official data base of EUROSTAT available for external users. It combines physical and valued data of several domains of EUROSTAT's agricultural statistics into a frame work consistent to the EAA, covering the EU member states in time series starting from 1973. The internal consistency and the activity based approach of the data base provide a natural starting point for any regionalization (Wolf, 1995). In other words, an aggregation of the main data items inside REGIO (areas, herd sizes, gross production and intermediate use, unit value prices and EAA-positions) over the regionalized data must recover the sectoral values of SPEL (Britz, 1997). As an example, the approach is explained for cereals:

The SPEL activities BARL (barley), MAIZ (grain maize) and PARI (paddy rice) match directly the information in REGIO, hence the regionalized data are set to the values in REGIO. The difference between the sum of these areas and the aggregate cereals in REGIO must be equal to the sum of the remaining activities in cereals as shown in SPEL, namely RYE (rye and meslin), OATS (oats) and OCER (other cereals). As long as no other regional information is available, the difference from REGIO is broken down applying sectoral shares.

The approach is shown for OATS in the following equations, where the suffix *r* stands for regional data:

$$LEVL_{OATS,r} = \left(CEREAL_r - WHEAT_r - BARLEY_r - MAIZEGR_r - RICE_r\right)$$
$$LEVL_{OATS,SPEL} \Big/ \left(LEVL_{OATS,SPEL} + LEVL_{RYE,SPEL} + LEVL_{OCER,SPEL}\right)$$

Similar equations are used to break down other aggregates and residual areas in REGIO.

From the obtained area and production by crop activity, quantity of energy and protein for grazing livestock and digestible lysine have been calculated and used to estimate the regional level of autonomy to fulfil livestock requirements.

4.2.4. Farm type

As explained in the introduction of the paragraph 4 (page 10), total number of farms in a region and number of farms per farm types concerned by livestock production in regional Eurostat database (2002) were extracted. The list of the farm types of interest is available inside Annex 1. Because the abundance of farms per farm type of interest is provided at NUTS1 or NUTS0 level for certain countries (BE, NL, DE, AU), we have calculated the proportion (% of the total number of farm in a region) of the farms included in each farm types from NUTS0 or NUTS1 data and applied these percentages to each corresponding NUTS2 region.

The value obtained should be used to verify that classification of the regions obtained from the profile of the animals assemblages is coherent with the regional statistics available.

5. General methodology of the regional zoning

Whatever the regional descriptor considered (climate, feeding strategy, cropping systems…), the same classification methodology has been applied. It corresponds to a pure statistical approach of clustering of the regions regarding the descriptors retained. The method is briefly described hereinafter.

For one given animal sector considered (CAMILK for instance) or all sectors in the case of the regional clustering of the animals assemblage, different dimensions have been considered (see § 4 – LPS descriptors, p 10). It concerned eight dimensions:

- the animals assemblages
- the climates
- the cropping systems
- the feeding strategies
- the manures production
- the level of intensification
- the level of production

- the environmental impact

Raw data were directly extracted from CAPRI and expressed as absolute (n) and relative (%) quantities. When needed, they were processed to obtain intensification, autonomies or again autosufficiency proxies and introduced inside six different tables addressing one specific livestock sector each inside JMP 6.0 (SAS Institute). Then, four successive steps of the classification methodology were applied:

- Step 1: Multivariate platform was used first to decide of the descriptors to retain: scatterplot matrix on correlations was used to point out correlations between pair of variables – correlations between two variables higher than 0.90 asked for the withdrawal of one of the two variables considered, generally the less informative or the one expressing absolute value. By this, relative variables are often conserved: it allowed cross comparison between regions or classes of regions independently of the magnitude of the remaining variable in the regions. For correlation higher than 0.8 (up to 0.9), subjective decision based on expert knowledge to withdraw or not a variable was decided according to the loss of information it induced.
- Step 2: Principal components analysis (PCA) on correlations was then processed onto the remaining variables. Varimax rotation of the first significant principal components (cumulative percentage ≥ 0.75) was done and the rotated coordinates of the regions (row labels) on the remaining components were saved into the table of variables.
- Step 3: Two-way hierarchical ascendant classification (HAC) – standardized Ward method was then processed on remaining variables from PCA. The HAC was ordered according to the first component obtained from PCA: it eased for the visualisation of the results of the clustering. When using the first principal component as the column by which to sort regions, the data is ordered by generally small values to generally large values simultaneously across all variables used. It also gave a colour map on the dendrogram that is sorted across all variables in overall descending order.
- Step 4: To determine the relevant number of clusters to be processed, the approach was to perform in parallel of the HAC in JMP, a Ward two-way HAC into Xlstat v8.0. This platform, at the opposite of JMP, proposes an automatic (statistic) determination of the number of cluster (N_C). Then, in JMP, HAC was repeated on the same variables for a number of clusters between N_C-3 and N_C+3. The final number of clusters to be kept was decided by exploring the interpretability of the results of analyses of variance (ANOVA – Student t-test when normal distribution and Kruskal-Wallis test when non-normal distribution) obtained onto the variables by cluster when number of clusters varied from N_C-3 to N_C+3.

6. European LPS particularities in regions

Before to discuss classifications describing each one of the livestock sector, a certain number of maps have been produced from the available data to illustrate the European particularities of the livestock production (all sectors confounded) at regional level; these results are briefly presented and discussed in this part.

6.1. General overview of the Livestock Production in Europe

Europe is leading world agriculture production: in 2002, the EU15 participation to the shares in world trade in agricultural products was more than 40% either for exportation and importation; agricultural products traded from/to EU15 represented a share closed to 10% of the total merchandise and primary products traded in the world (WTO, 2003). But agricultural production in Europe is not uniform; agriculture production is differently distributed over Europe from one country to another as well as from one region in a country to another region. The mapping of the agriculture production – expressed as the revenue from crops and livestock production in a region (Figure 4) – shows that the main countries participating to the annual European agriculture revenue are the Denmark, France, Germany, Ireland, Italy and Spain. However, other countries such as the Greece, Netherlands, Portugal or again the United Kingdom appeared as important as the former; the difference is just that their agricultural production is more concentrated in few regions of production (Portugal, Netherlands) or more uniformly dispatched (and consequently lower) across all the country (United Kingdom). Figure 4 also shows that the total 2002 European revenue was mainly a consequence of the agriculture productions of Western countries located onto the Atlantic and Mediterranean perimeter.

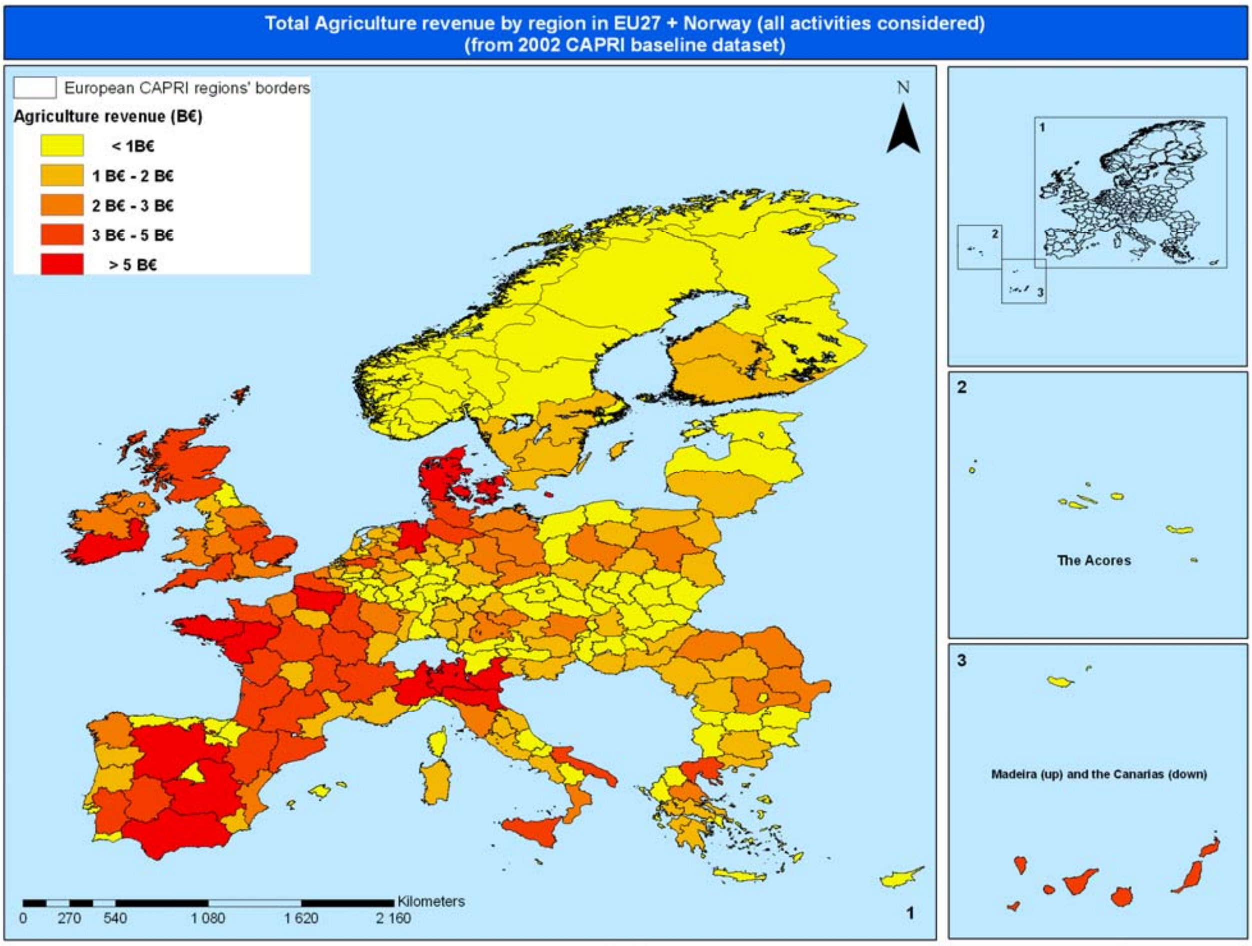

Figure 4: Mapping of the total agriculture revenue (B€) per region in EU27 + Norway

However, this figure tended to disadvantage regions with a limited potential area of agricultural production. This has been corrected by considering agriculture revenue relatively to the total used arable area (UAA) in a region (Figure 5). European regions presenting the higher revenue per hectare of UAA were found in Belgium (BE21[18], BE22 and BE25), in Italy (ITC4, ITD3, ITD5), in France (FR52), in Germany (DE94, DEA3), quite all the regions in the Netherlands and the Rogaland region in Norway. Cyprus, the Canarias (ES70) and Madeira (PT30) were also of interest.

[18] The table of the NUTS0, NUTS2 codes and names of the regions considered inside CAPRI is given in annex 2

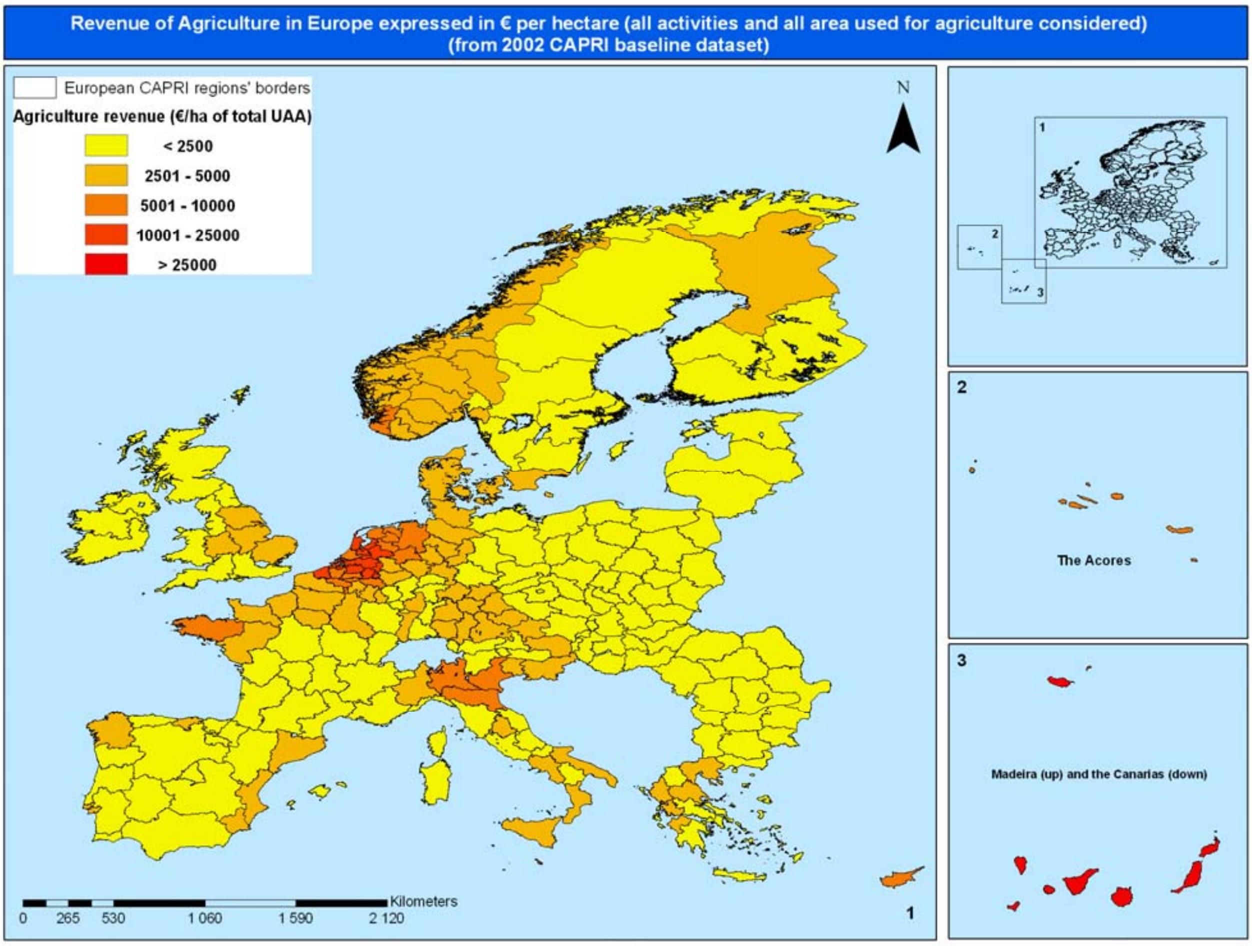

Figure 5: Mapping of the relative regional agriculture revenue (€/ha of total UAA) in EU27 + Norway

For 2002, we have then considered the share (%) of the livestock revenue (all the six livestock sectors together) in the total agriculture revenue (Figure 6). Expressed as a percentage of the total agriculture revenue, it suggested the importance of the livestock production for the regional agriculture economy and allowed the different regions to be compared independently of the absolute livestock revenue observed in a region. On the other hand, it asks from the reader an effort to consider the predominant regions for livestock production (Figure 6) and the total agriculture revenue (Figure 4) together.

The European regions presenting the highest (≥ 80%) share of the livestock production were situated on a SW-NE axis, from northern Portugal to Norway, including Denmark, Ireland, The Netherlands and the United Kingdom. Another predominant zone for livestock production was centred on the Alpine massif and contains French, Italian and Austrian regions. Furthermore, Catalunia in Spain, Auvergne in France and Stredné Slovensko in Slovakia are few isolated regions where the share of the livestock production remained important.

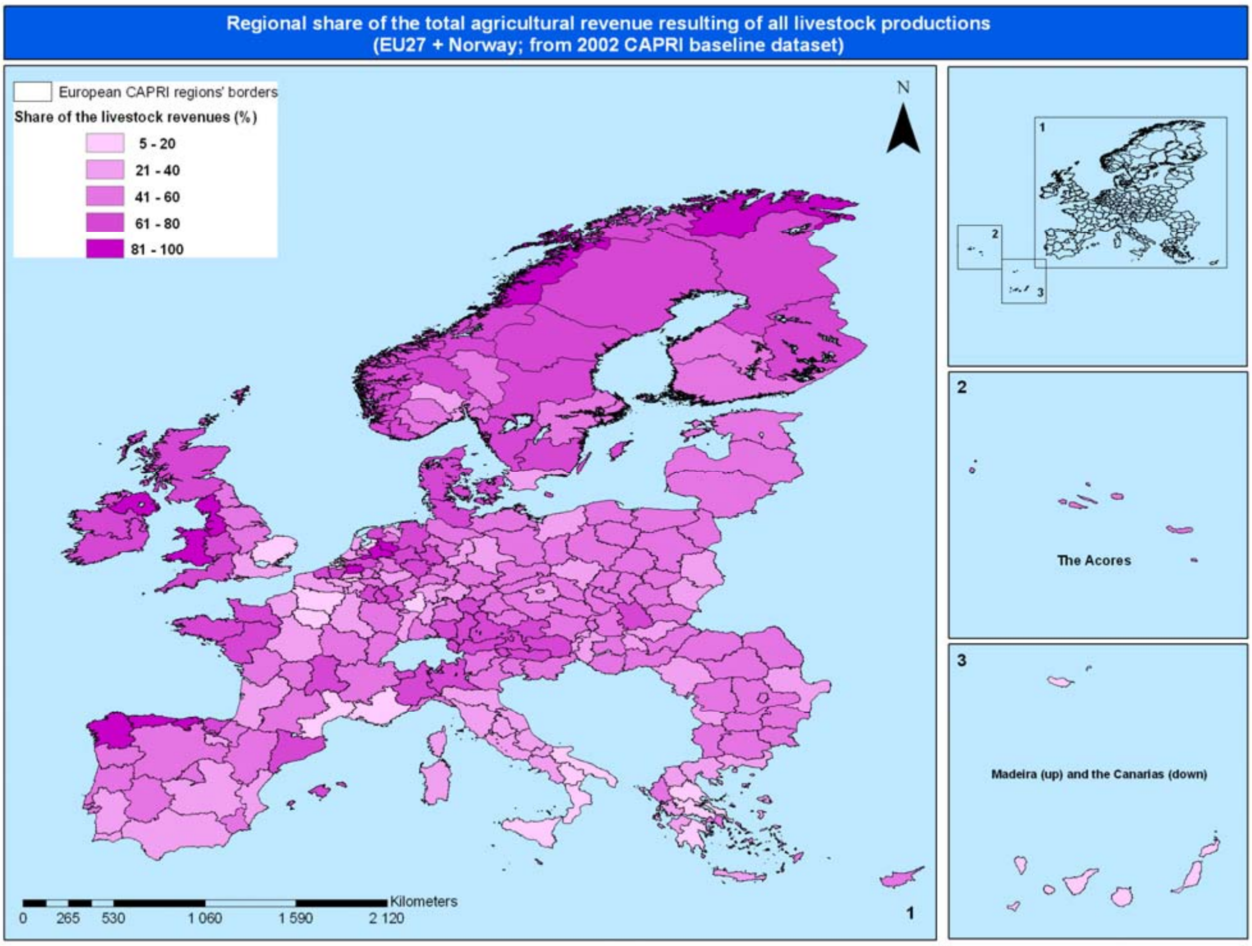

Figure 6: Regional share (%) of the livestock production in the total agriculture revenue in EU27 + Norway

From this, we assumed concentration of the livestock production along the Atlantic border could be climate-dependent. Here, the importance of sufficient precipitation a year for low latitudes or temperate temperature for medium latitude could explain the trend observed: these meteorological conditions could be considered as favourable for the fodder biomass production. In the same time, we could assume that climatic-limited situations such as mountainous or Scandinavian climates (higher latitude), plant production becomes impossible or cost-ineffective and livestock production is the sole farming adapted to the agro-climatic potential.

Inherent to the method of calculation, the share of the plant revenue in the total of the agriculture revenue is the complement to the share of the livestock revenue (Figure 7). The main regions for which plant production is the major source of revenues are logically those presenting a low share of livestock production. It concerned the south of Spain, the south and north of France, the Eastern region in the United Kingdom, and a large part of the Greek regions.

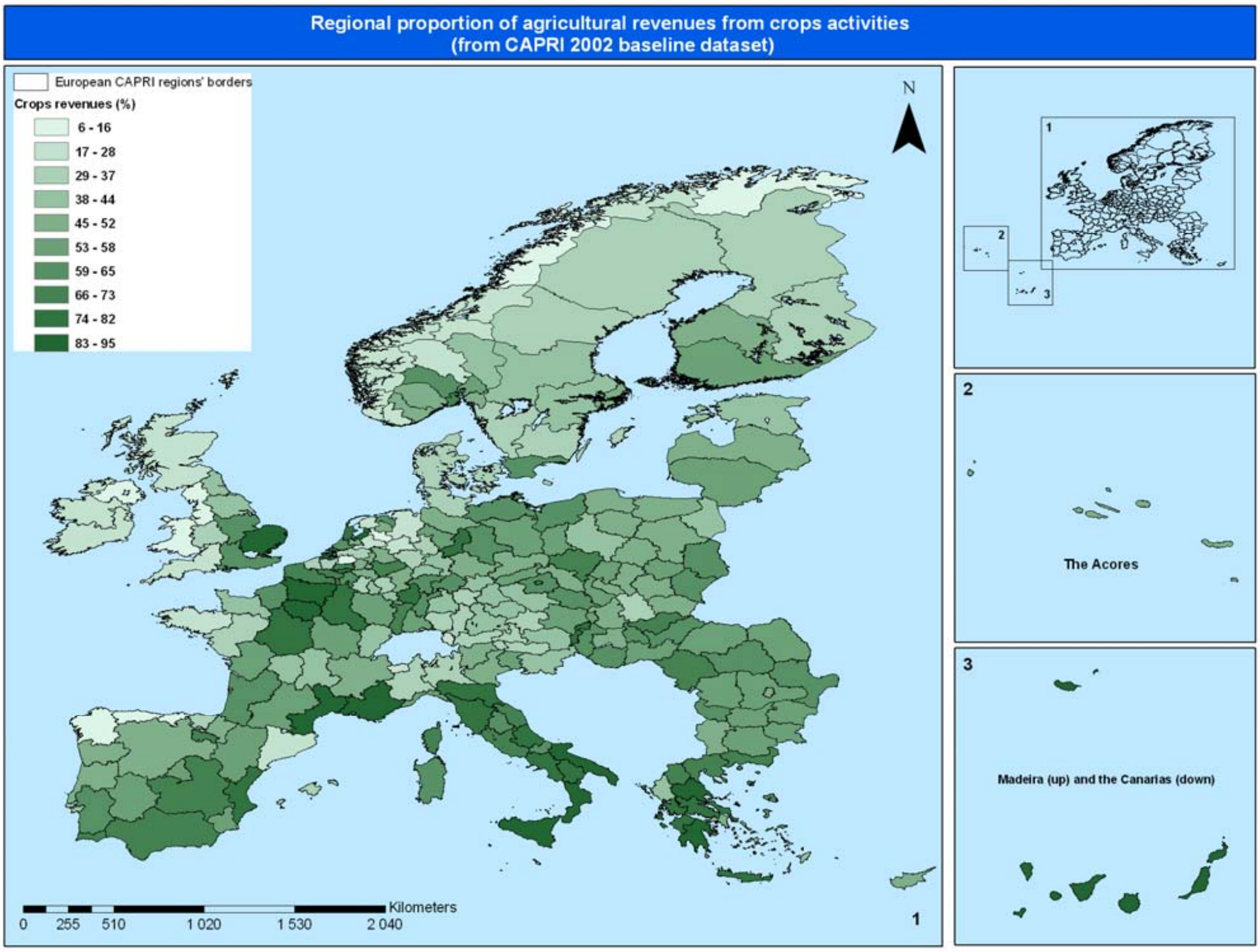

Figure 7: Regional share (%) of the plant production in the total agriculture revenue in EU27 + Norway

From the last two figures, we can remark that the majority of the regions localised in the Eastern Europe present a relatively well balanced share of the total revenue between plant and livestock production. At the opposite of certain western European regions considered as very specialized, eastern European regions appear as less differentiated and less specialized. However this result could be biased due to the fact that all activities have been merged to calculate the agriculture and the plant and livestock revenues. By considering livestock sectors independently, a balanced region for livestock production could become later a very specialized region because of livestock revenue originated from one single livestock sector. This confirms the necessity to conduct further analysis separately for each one of the livestock sectors and to address in depth "regional herd size" and "regional herd composition".

Herds assemblages would be addressed later in this document (§ - 6.2.1.). Before that, the total number of livestock units (all livestock sectors together) has been calculated and mapped (Figure 8). The denser regions observed for 2002 were situated in a limited number of European countries those already pointed out by Burton & Turner (2003). They were the Weser-Ens region in Germany, all the Denmark, the Castilla-Leon region in Spain, almost all Ireland, the Bretagne and Pays de la Loire regions in France, all the north of Italy from the Piemonte to the Veneto region, the Noord Brabant region in the Netherlands and the South-Eastern region of the United Kingdom plus Scotland. Dense livestock populations were also localised in Eastern Europe regions: the Mezowiecke and Wielkopolskie regions in Poland, Lithuania and the Nord-East region of Romania.

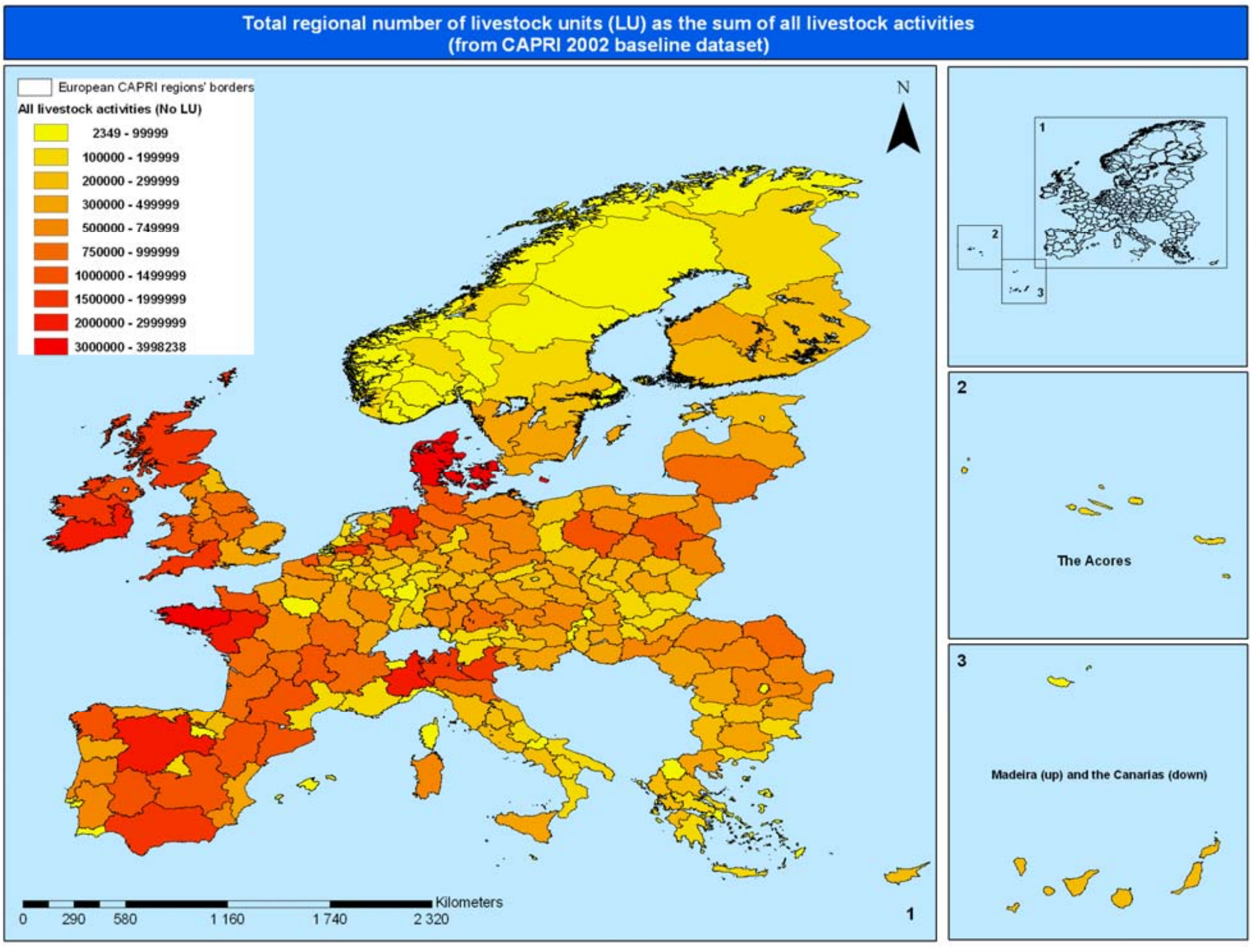

Figure 8: Regional distribution of the total number of livestock units (LU) in EU27 + Norway

When crossed, the share of the livestock revenue and the total number of livestock units coincide well. However, certain regions such as Scandinavian regions are not highlighted in Figure 8; furthermore, some other regions (the Polish ones for instance) appear in figure 8 when they have not been identified as predominant for livestock revenue; this points out the fact that revenue per livestock unit is also important. This confirms that share of the livestock revenue cannot be consider alone; supplementary quantitative information such as the number of livestock units or the produced quantities of livestock products (which are generally very strongly correlated) must be consider when an accurate clustering of the regions is expected.

Logically, when considering the manure production (expressed as the quantity of nitrogen per hectare of arable land) we show that the regions with the highest quantity of nitrogen-from-manures (Figure 9) correspond to almost all the main dense regions. The trend is also valid for phosphorus and potassium. If most of the regions with a dense population of livestock units presented an applicable amount of N-manures inferior or closed to 170 kg per hectare (Reg. EEC No. 676/1991), some of the regions have N-manures availability exceeding this threshold.

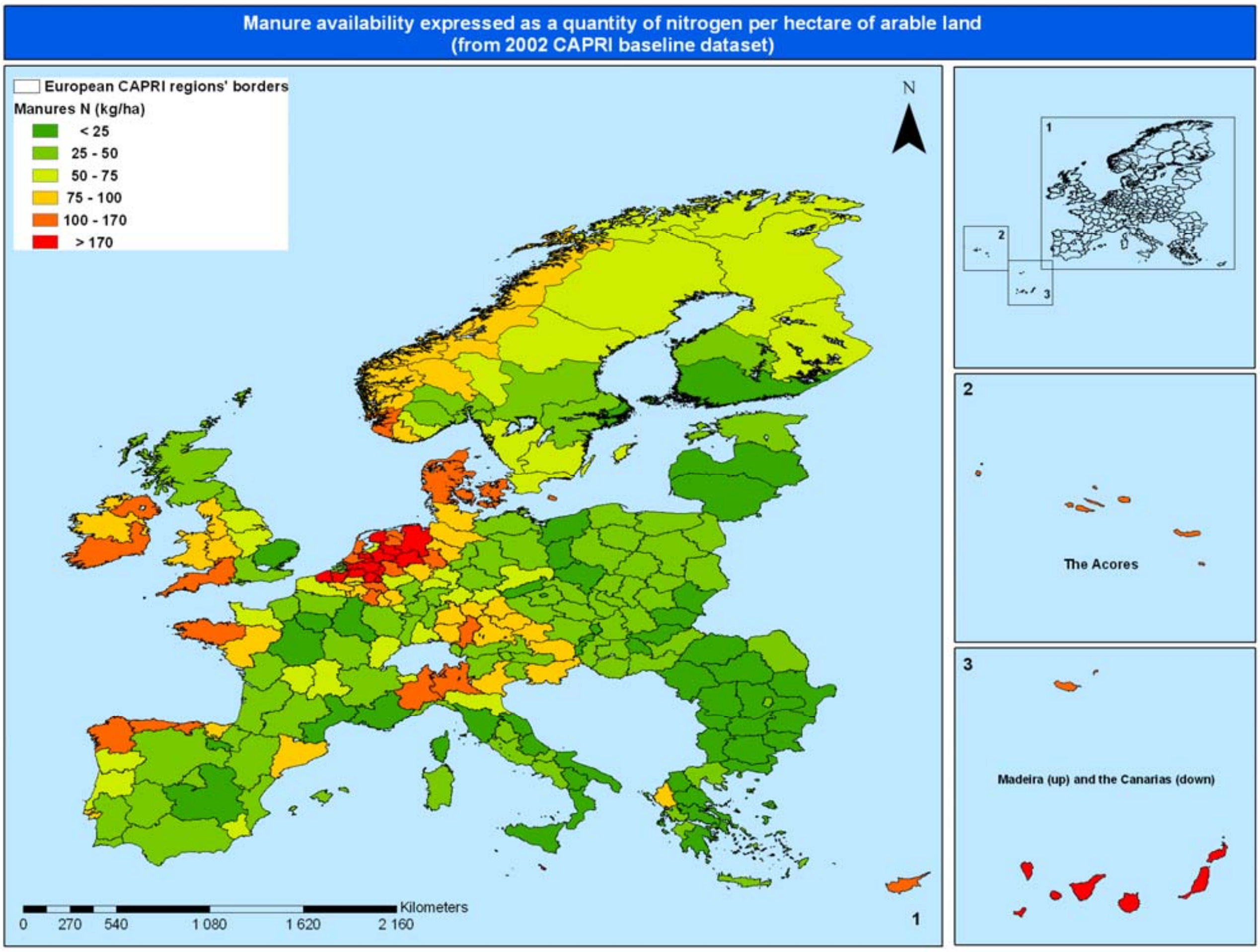

Figure 9: Regional distribution of the nitrogen-from-manures availability per hectare of arable land in EU27 + Norway

It concerned regions concentrated in Belgium (BE21, BE22, BE23, BE25) in the Netherlands (NL12, NL21, NL22, NL31, NL41, NL42), in Germany (DE94, DEA3), The Canarias (ES70) in Spain and Malta (MT). On the other hand, certain regions with a high total number of livestock units (in France, Ireland, Italy or in the United Kingdom) do not show N-manures availability exceeding 170 kgN/ha threshold. However, all these regions are considered as regions in Europe where the pollution of surface and ground waters by nitrate from livestock production is at very high risk. According to the specific climatic conditions met in these regions, decisions concerning the spreading practices are crucial for the protection of the agricultural resources and adapted manures management strategies (storage and spreading facilities) are requested.

Together with the estimated quantities of nitrogen applied from fertilizers and the residual nitrogen from crops, the N-surplus per hectare of arable land has been estimated within CAPRI and mapped (Figure 10). It corresponds to the quantity of nitrogen that cultivated plants on arable land cannot assimilate – crops nitrogen requirements being already fulfilled. Almost all the regions identified as predominant for livestock production (independently of the dominant livestock sector in place) present a very high (>75kgN/ha) N-surplus. It concerned regions located along the Atlantic SW-NE axis, around the Alpine massif and in lesser extent in the north of Finland.

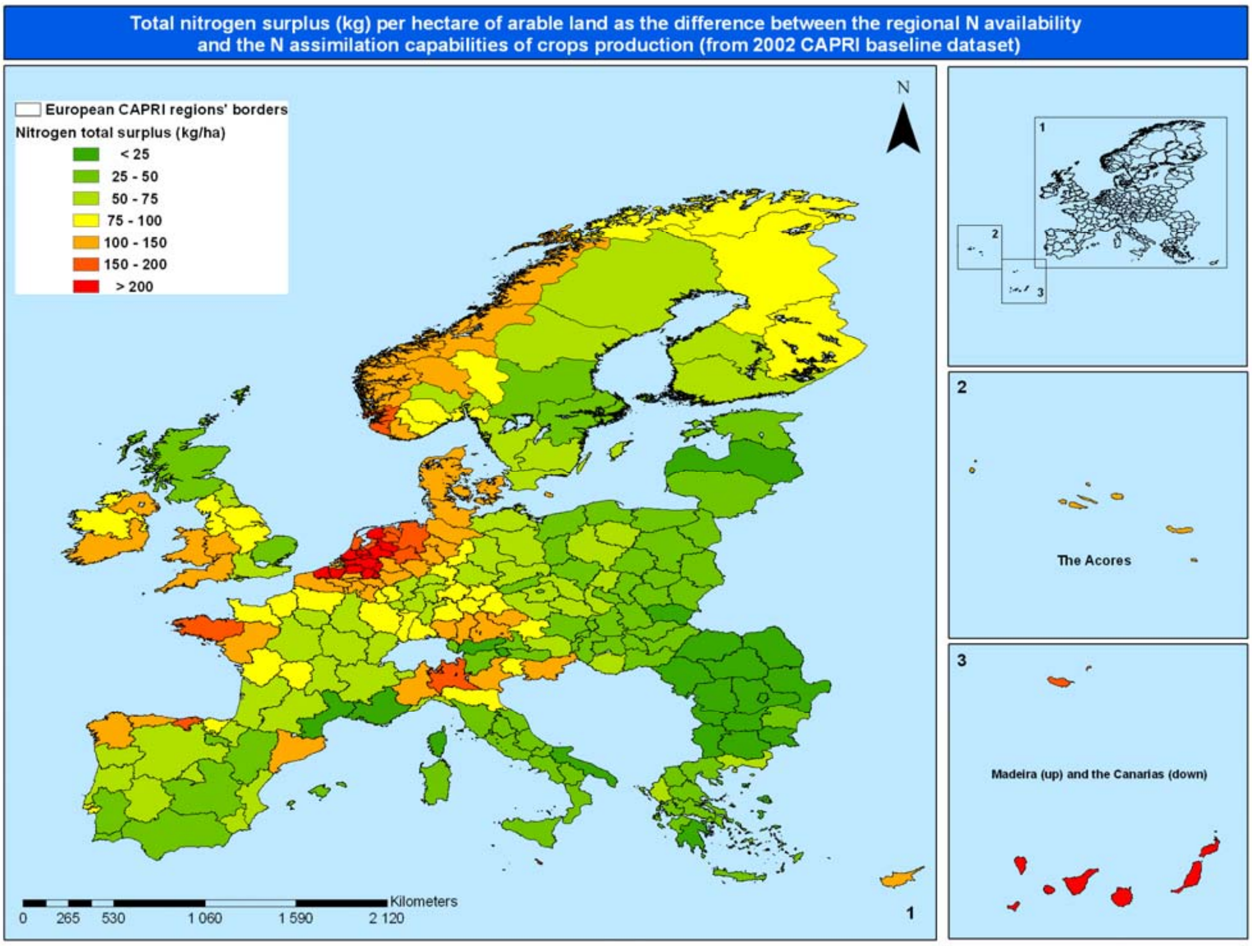

Figure 10: Regional distribution of the total nitrogen surplus (manures + fertilizer + crops residues) per hectare of arable land in EU27 + Norway as an indicator of the water-ground pollution by nitrate risk

Surprisingly, in Eastern Europe, none of the regions with relatively dense livestock population are presenting a high N-surplus. At the opposite regions in Bulgaria and Romania appeared as the less exposed to a water-ground pollution by nitrate (phosphorus and potassium as well). Another remarkable point concerned the Mediterranean regions. Despite the fact that some of the Italian, Spanish and Greek regions were identified as regions with medium livestock population density, they didn't present a high risk for ground-waters pollution by nitrate. Two main reasons could explain this trend: (i) very large cultivated areas proportionally to the livestock herd size (and manures availability) allow farmers to practice an efficient spreading of the manures with a low risk of ground-waters pollution by nitrate; (ii) the nature of the livestock reared in these regions is less manures-productive and limits the risk of pollution; in this case analyse of the animals assemblage and predominant livestock sectors in place should be determinant.

6.2. Climatic, animals assemblages and cropping systems classifications

Prior to the sector-specific classification of the production systems (LPS), stratification of the whole number of regions by a limited number of climatic zones or by the livestock sector predominance or again by the cropping systems in place was possible. It has been considered because stratification generally eases the interpretation of the clusters obtained. Decision was taken to target robustness rather than interpretability of the results and stratification anterior to the classifications was not performed : regarding the limited number of regions (243 in total) stratified population would limit greatly the final number of regions per class of LPS and the rule of thumb was to obtain at least ten regions by cluster. Consequently, classifications dedicated to climatic, cropping systems and animals assemblages were operated separately. This solution asked for a supplementary effort of interpretation to cross by-sector classification results with climatic, cropping system and animals assemblages classification results when deciding of the final regions to be surveyed. But it remained possible.

6.2.1. Climatic classification

The climatic classification was processed following the in-4-steps classification method explained in the paragraph § - 5. From seventeen initial variables and after identification and reduction of the highest correlations, only three variables were retained:

- the cumulative sum of the daily temperature for the 6 first months
- the number of freezing days a year
- the precipitations registered for the year

In the same time, but separately, elevation classification was processed from averaged regional elevation and dispersion index of the elevation (as the elevation uniformity in a region). Concerning meteorological data, the first three components of the PCA absorbed almost 90% of the data variability. Varimax rotation was then executed onto the three first components. The clustering of the 243 regions has been processed over a number of clusters from 5 to 11 for the meteorological variables and from 2 to 8 for elevation variables; the final number was 8 and 5 respectively for climatic and elevation clusters. Distinction and description of the climatic and elevation clusters was made from analyse of variances (normal distribution being verified) performed onto the clustering variables and several other variables. The results of ANOVA are summarized in annex 3 and 4 for the principal descriptive variables. The general rule-of-thumb to obtain at least 10 regions per cluster was not possible; even the reduction of the number of cluster to 5 didn't allow us to obtain clusters with more than 9 regions.

The eight different climates identified can be described as follows (Figure 11):

- Cluster 1 – "Oceanic temperate": situated between the 45°N and 55°N latitudes, it corresponds to a temperate climate (intermediary cumulated daily temperatures with a very low number of freezing days) under oceanic influence (high number of rainy days, but medium to low precipitation abundance per day). These are regions of Western Europe very closed to the Atlantic Ocean and the North Sea: North of France, Belgium, the Luxemburg, the Netherlands, part of the United Kingdom and Ireland and western Germany. These regions correspond generally to sea level regions and in less extent to regions with hilly relief (Figure 12): they are regions with low to very low elevation and a low index of elevation dispersion index describing flat to very flat regions.
- Cluster 2 – "Oceanic cold": this climate is very similar to the previous one with higher quantities of rainfall a year and colder temperature. The radiation is low to very low due to the fact that these regions are situated between 55°N and 65°N latitudes. Under both the polar influence (cold temperature) and the oceanic influence (very wet), these regions have a high number of rainy days and a total precipitation a year the highest in Europe. It concerns only few regions localised on the south Scandinavian peninsula in Norway and the Salzburg and Vorarlberg regions in Austria.
- Cluster 3 – "Mediterranean dry": climate very hot and dry, the regions concerned are under the sub-Sahara influence. Generally situated between the 35°N and the 45°N latitudes, it

corresponds to the southern regions of Spain, Italy and Greece and almost all the Mediterranean archipelagos. Cumulated daily temperature and solar radiation are very high and these regions are benefiting of the larger favourable temperature window for crops growth; however, the lack of precipitation reduces greatly the advantage of the thermal condition by inducing high evapotranspiration and hydric deficit. For annual crops, these regions generally have recourse to irrigation.

- Cluster 4 – "Continental temperate": situated onto an N-SE axis, the regions under the influence to this climate correspond to almost all the central eastern European region, from Denmark to Bulgaria. All the meteorological variables considered depict medium values: with intermediate precipitation, number of freezing and rainy days, a medium cumulated radiation and daily temperature, this climate is more constant one. Because this climate concern regions closed to the ocean as well as regions situated in the Carpathian and Balkan massifs, the corresponding range of elevation fluctuates from low to medium elevation and from low to medium elevation dispersion.
- Cluster 5 – "Continental cold": situated at the interface between the polar and continental influence, the continental cold differs from the previous climate by colder temperatures and higher precipitation. The corresponding regions are situated around the Baltic Sea: Sweden, Finland, Estonia, Latvia, Lithuania and some regions of Norway. They present very low elevation and relatively flat landscape (Elevation – Cluster 2). These conditions are generally considered as favourable to agriculture by facilitating the use of heavy machinery. Despite this, localisation at relatively high latitudes (from 55°N to 70°N) confers to these regions a much more reduced potential for plant cultivation: radiation and cumulated daily temperature are among the lowest in Europe.
- Cluster 6 – "Mediterranean wet": when compared to cluster 3 "Mediterranean dry climate", the conditions met for cluster 6 appear friendlier. Beside high cumulated temperatures and radiation, the corresponding regions benefit of more important and more regular precipitations (724.7mm ± 82.2 against 482.2mm ± 91.4); this counterbalancing the disadvantages observed for cluster 3. Consequently, this cluster can be considered as the best compromise for the cultivation of annual and perennial crops. The regions influenced by this climate are situated between 40°N and 45°N latitudes and are the north of Spain, north of Italy and Greece and the south of France. They correspond to medium mountains' elevation more or less erratic.
- Cluster 7 – "Alpine": almost all these regions concerned are belonging to elevation clusters 3 and 5: they are situated in medium to high mountainous zones. It concerns Austria, extreme north of Italy, Slovenia, The Limousin and Franche Conté regions in France, the Norte region in Portugal, Scotland and Wales in the UK, the extreme south east of Germany and the Vaestsverige region in Sweden. They receive a medium amount of radiation and they present medium temperatures with a medium number of freezing days. However, the precipitations are important as well as the number of rainy days. The number of snowy days (68.48 ± 47.42) is medium when compared to those observed for the Oceanic cold climate (151.68 ± 18.93) and the Arctic climate (212.89 ± 18.17).
- Cluster 8 – "Arctic": finally, the last regions, localised between the 62°N and 72°N latitudes, are concerning the Scandinavian Peninsula. They are under the influence of a very cold and dry climate with a very high number of rainy days. The climatic window can be considered as the worst for agriculture activities: cumulated radiation and temperature are the lowest in Europe; the number of freezing days is 149.6 (± 10.7). Elevation varies from low to medium as well the elevation dispersion.

From this first results, interpretation of the climatic and elevation clusters all together remained an easy thing. However, the elevation classes do not match correctly the climatic clusters obtained: several climatic clusters are presenting a very large range of elevation and uniformity. To go beyond this, a reduced number of elevation classes is conceivable. For instance, socioeconomic models such as AROPAj[19] are considering three elevation classes (≤300m,]300m-600m], >600m) when clustering farm types and/or farming systems. In our case, the reduction to three elevation classes was more convenient for elevation classification interpretation[20] but very limited when related to the climates (for instance, elevation class 2 counted regions with climates 1, 2, 4, 6, and 8). Reduction of the number of elevation classes was then not meaningful and 5 classes of elevation were kept. On the other hand, it validates the method of deciding of the number of classes from a range of clusters centred onto a number automatically determined from statistics.

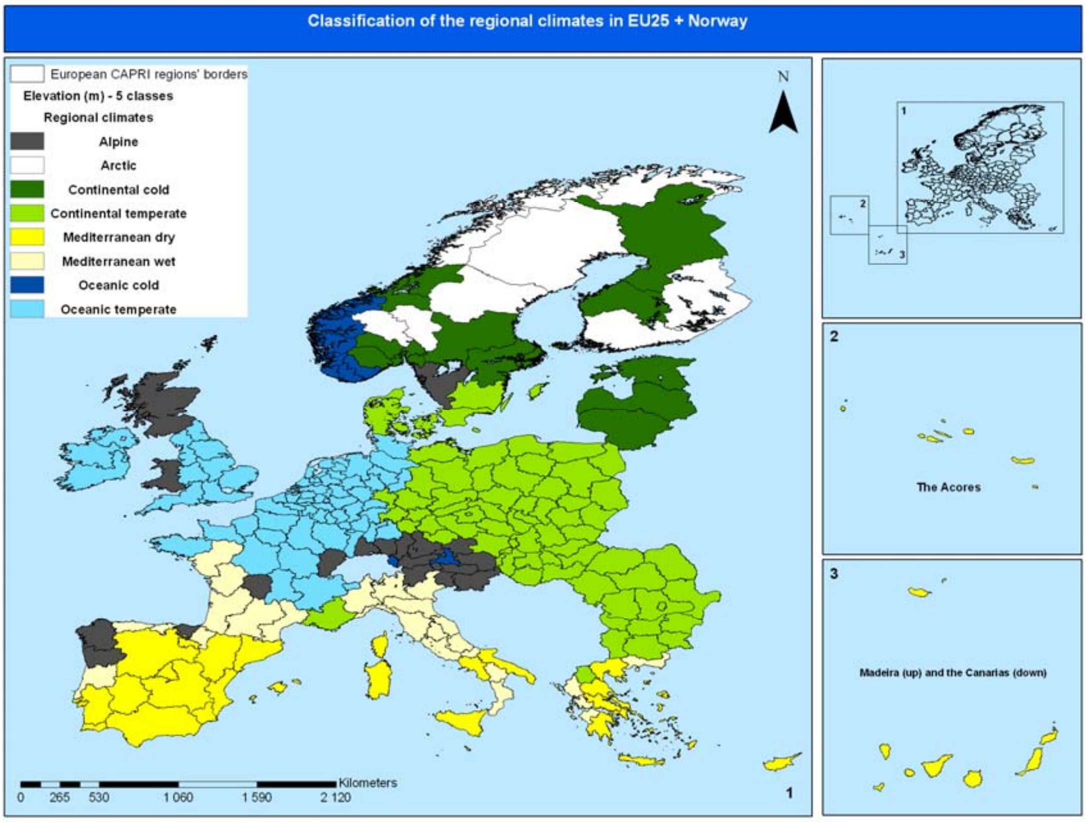

Figure 11: Mapping of the eight main climates identified in EU27 + Norway

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[19] http://www.grignon.inra.fr/economie-publique/MIRAjE/model/detail.htm

[20] If three elevation clusters would be decided, averages and standard deviations would be 691.56 (436.79), 101.75 (65.36), 445.32 (11.78) and 424.63 (167.74), 26.66 (23.42), 131.98 (76.34) for elevation and elevation dispersion respectively for clusters 1 (n=38), 2 (n=112) and 3 (n=93)

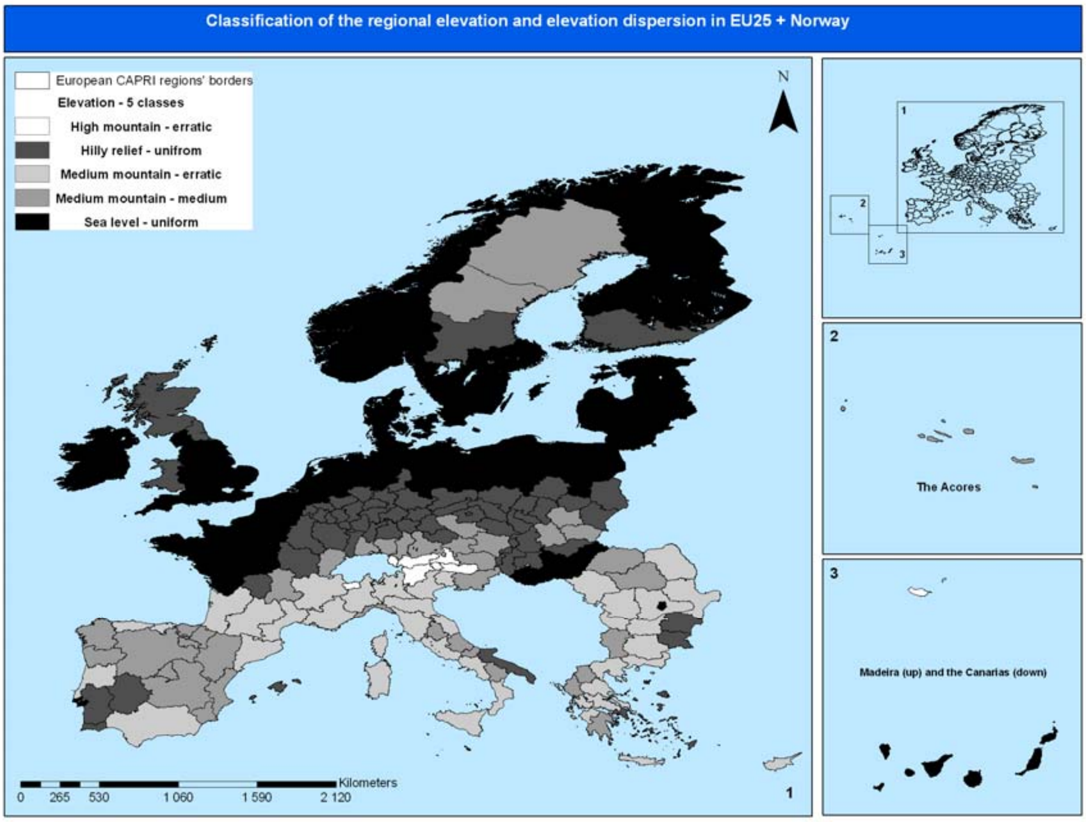

Figure 12: Mapping of the five main elevation classes identified in EU27 + Norway

6.2.1. Animals assemblage classification

The animals assemblage classification was performed following the same method. The data used was the absolute abundance of livestock units per livestock sector from which the by-pairs of region Morisita's index of similarity has been calculated and compiled into a double matrix of similarity (see § - 4.2.2). From the automatic and successive HAC, ten clusters were decided. In parallel, the relative abundance (%) of each livestock sector in the total number of LU was calculated per region. Averages and standard deviations per cluster (as well as ANOVA performance) are shown in annex 5.

Despite cluster 7, all other clusters present at least one livestock sector for which the averaged percentage obtained was higher than the 75th percentile obtained from the analyses of the distribution per sector (n=243). More than half of the clusters show two or three major livestock sectors participating to the animals assemblages. Cluster 7 is the sole cluster for which the percentage obtained is higher than the 50th percentile but smaller than the 75th percentile; no livestock sector is really dominant in cluster 7. From these values, we have proposed a denomination of each one of the clusters by considering the two first livestock sectors participating to the animals assemblages and by respecting the hierarchy of participation. In some cases, because three different livestock sectors participated equally to the animals assemblage, a unique identifier expressing a common aspect to the three sectors was preferred. Regional mapping of the final ten clusters is presenting in figure 12; the different denominations attributed to each one of the clusters are:

- Whatever the number of clusters tested during the HAC (step 3, see § 5.), one of the regions was always identified alone as ovine-dominant. This described a very strong differentiation of the region according to its animals assemblage. This region was the Kriti region in Greece (EL43): more than 85% of the whole regional herd (in LU) in 2002 was composed by SHGOAT. Consequently, EL43 has been considered alone as ”OVINE”.

- Cluster 2 “GRANIVORES / OVINE”: in this cluster, the main productions were the pigs for fattening production and the broilers productions (≥ 75 percentiles); laying hens production was less important but present mean value higher than the 50 percentiles. In the same time, ovine production was also very important (≥ 75 percentiles). This cluster was consequently called “granivores / ovine”, with granivores corresponding to poultry and pigs productions together. The seven regions identified as “granivores / ovine” are eastern Spanish regions and Cyprus. This cluster is describing situations where monogastric livestock production is predominant over other livestock productions under the influence of Mediterranean dry or wet climates (as described in §-6.2.1.). Preference of rearing little grazing animals and monogastric livestock could be partly explained by the limitative climatic conditions and limited pasture production (and share); it should also requires livestock facilities such as cooling systems, automatic feedstuffs distribution to avoid stresses during production and logically involves indoor production systems.
- Cluster 3 “OVINE / BOVINE”: when compared to the two first clusters, the ovine / bovine cluster is differentiated by the fact that bovine livestock for meat are reared together with ovine livestock – ovine staying the dominant production. The regions belonging to this cluster are very dispatched across Europe – from extreme south of Spain to Norway, in Greece and Ireland. In this cluster, sheep’s and goats for meat or milk remains the dominant livestock production (≥ 75 percentiles); and cattle meat production seems to be associated to the latter. This association of grazing livestock is certainly very different fro one region to another, even more from one country to another. One could imagine that feeding corresponds to very intensive indoor production (south of Spain) or to free / rotational grazing of mountainous alpages (in northern Greece, in Provence Cote d’Azur and Corse region sin France or again in Sicilia and Sardegna regions in Italy). On the other hand, “Ovine / bovine” production under higher latitudes such as in Ireland would have recourse to grazing of temporary or permanent pastures at high potential yield and haymaking.
- Cluster 4 “BOVINE / OVINE”: the increase of the bovine livestock share leads to livestock productions targeting bovine production first. Cluster 4 corresponds first to milk and meat cattle production – other livestock productions appear as subsidiary. Regions concerned are situated closed to the Pyrenean chain in France and in Italy benefiting of Mediterranean wet or oceanic conditions in Ireland and Norway.
- Cluster 5 “BOVINE”: together with clusters 7 (n=47) and cluster 8 (n=40), this cluster is one the largest clusters when considering the number of regions it contains (n=46). The bovine cluster presents a large proportion (75% approximately) of livestock destined for milk and meat production from cattle. The corresponding regions are localised in the western Europe at medium latitude and in the northern Europe in Latvia, Lithuania, Estonia and in the Scandinavian peninsula. The presence of bovine productions in these regions could be a consequence of (i) a priority given to grasslands because of too limitative conditions for plants production (high latitudes) or (ii) a locally specialized bovine production due to cultural/historical or sectors facilities at lower latitudes (as in north west of France, south of Germany, Austria).
- Cluster 6 “GRAZING”: Other region specialized in bovine production, especially bovine meat production, are sometimes grouped in less favourable regions as hilly relief or medium mountainous regions (Auvergne and Franche conté regions in France, the Trentino-Alto

Adige region in Italy, the Tyrol region in Austria). In the same cluster, other regions closed to the sea-level (the North-west and south-east regions in the UK) under the influence of oceanic climate or regions under continental cold or even artic climates are presenting animals assemblage classified as bovine (Finnmark and Nordland regions in Norway or Mellersta Noorland in Sweden). If all these regions have a bovine dominant production, they present at less extent a certain SHGOAT share.

- Cluster 7 <u>"MIXED without SHGOAT"</u>: In this cluster, none of the six livestock sector is dominant and sheep's and goats production is generally very limited. Bovine for milk as well as pig and in a less extent poultry productions are the major (≥50 percentiles) productions describing this cluster. These regions are clumped in central and eastern parts of Europe, from the Netherlands to Poland. It also concerns north of Italy and some regions in the Scandinavian Peninsula.

For the remaining clusters, regions are more disseminated over EU27+Norway; for them, livestock productions are generally conducted indoor so that climate or relief do not influence so much as assumed for the previous clusters.

- Cluster 8 <u>"GRANIVORES"</u>: all the three monogastric categories of livestock appear as preponderant in this cluster. Pigs as well as poultry (LAHENS and POUFAT) productions are the major sources of revenues from livestock in the concerned regions when grazing livestock activities are very weak. A large number of countries are concerned by the granivores production: Belgium, Germany, Portugal, France, Poland, Austria, UK etc. If almost all the countries present one single region specialized in granivores production, Poland, Hungary, south Netherlands and northwest Germany at the opposite seem to have a large part of their territory dedicated to such a production. As expected, the random location of the granivores regions indicates that climate conditions only slightly decide of the organization of the granivores sector. Same trend are observed for the last cluster (cluster N°10).
- Cluster 9 <u>"OVINE / POULTRY"</u>: this cluster does not count a high number of regions and appears to a certain extent related to the local farming culture and history. Seven of the eight regions concerned are Greek; the last one is the Spanish Canarias region. The animals assemblage found for these regions excludes cattle breeding and pigs production. Only little grazing (ovine) and monogastric livestock are reared. We assumed that this choice is related to a limited crop production potential which does not allow feedstuffs auto consumption and would require to farmers very high feeding investments in the case where cattle and pigs would be produced.
- Cluster 10 <u>"POULTRY"</u>: as stated for cluster 8, only few countries are concerned by a dominant poultry production (POUFAT and LAHENS). Most of them are located in Spain, France, UK, Italy, Romania, Bulgaria and in Norway suggesting that if climate is less influent than for pigs production, the trend is even so to localize poultry production at low latitudes. One could suggest that it may limit heating and cooling costs or corresponds to crops productions dedicated to poultry production (cereals, maize grain…).

From this animals assemblage classification, a large range of regional predominance has been observed. On the one hand, ovine and bovine livestock appeared as organized in regions according to a certain climatic gradient and could be related to the availability and the potential production of fodders. On the other hand, some sector are less climatic-dependent; the "granivores" specialized regions are for instance very dispatched over Europe and do not match any of the agroclimatic gradient. This suggests a less climate-related influence on the monogastric productions: indoor and less land use-dependent, poultry and pig productions can be established everywhere in Europe.

Limitations could be the logistical and sector facilities necessary to collect and transform the production (Burton & Turner, 2003).

This classification also suggests that ovine and poultry productions could be strongly related to cultural and historical practices locally decided along time and that granivores production appear as more specialized in region than other livestock sectors. Once again, without any other meaningful explanation, we assumed that the potential cropping system and the potential of biomass production are the major levers deciding of the size and nature of the livestock to be reared in a region. This should not exclude other possibilities such as cultural or commercial influences.

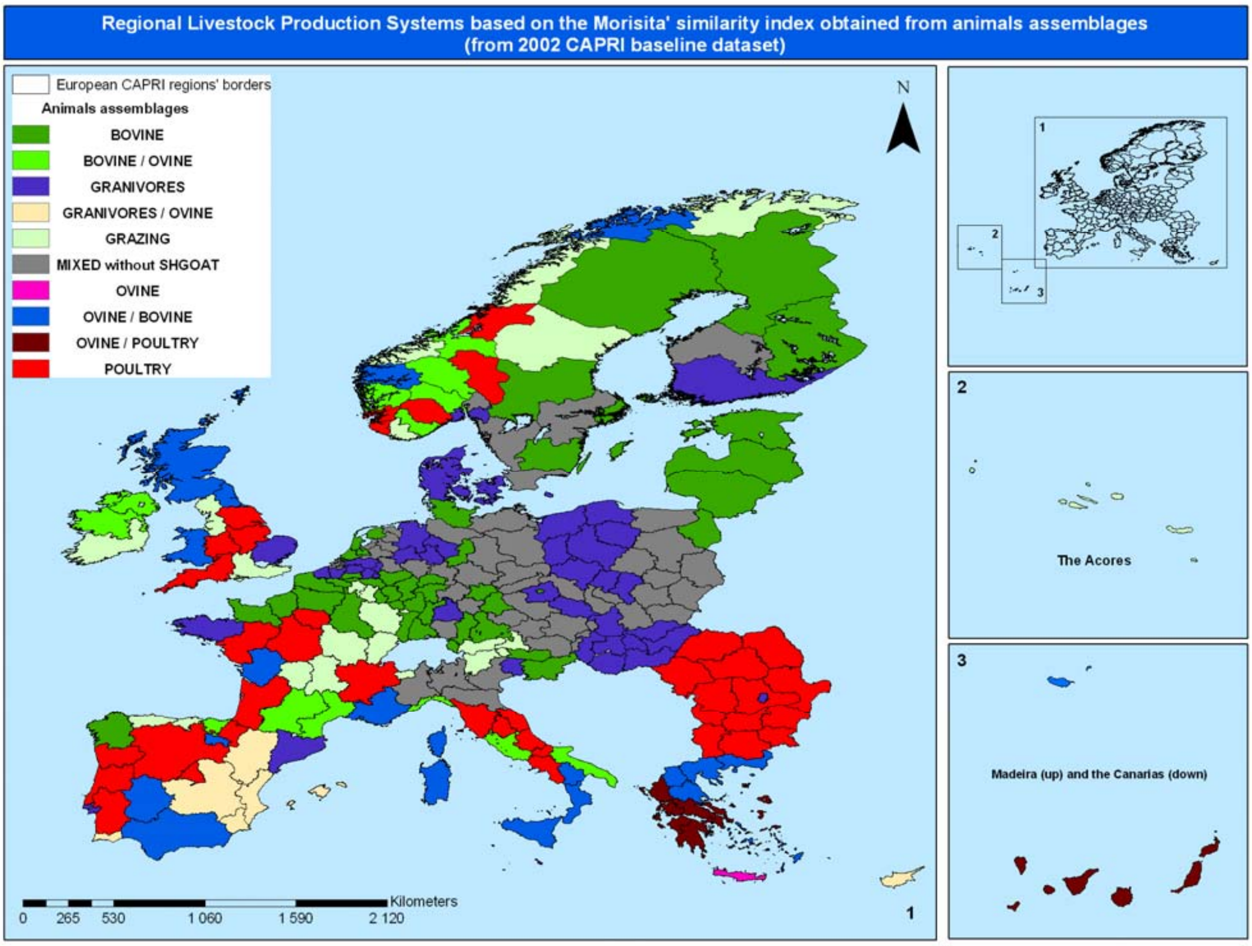

Figure 12: Animals assemblages mapping in EU27 + Norway

The relevance of this classification has been later verified by comparing animals assemblage in a region and European data. From Eurostat, the number of farms per farm types concerned by livestock production has been extracted for 2002. The share (%) of each farm type in the total number of farms was calculated and used to estimate if the animals assemblage classification provides us a valid interpretation of the livestock production in region. Results are shown in annex 6.

Almost all the farm types considered are matching the clusters obtained from classification onto the animals assemblages. Farm types T41, T42 and T43 concerning cattle breeding are well distributed inside the "BOVINE / …" as well as the "… / BOVINE" clusters. Same trend is observed for sheeps' and goats versus "OVINE" and granivores versus "GRANIVORES". However, certain farm types such as T71 and T82 are less well distributed inside the animals assemblage clusters. For instance, T71 – "Mixed grazing" farm type should present a high share for clusters 3, 4, 5, 6 and 7 which are the main clusters where grazing livestock are reared. At the contrary, only clusters 1, 9 and 10 present a high share of T71 – “Mixed grazing” farms. This doesn’t signify that our classification is wrong – but it suggests that discrepancy between the two methods exist. Farm type is determined from the economic valuation of each one of the production activities existing on farm (crops as well as livestock production activities are considered for T82 – “crops + livestock” for instance) from surveys. From this, the farm type is decided by considering the first or two first largest activities. To be comparable between European countries or regions, the economic values are expressed in standardized economic size units (ESU) of the farms. However, even if activities are standardized in a second step, initial economic values are different between countries and regions so that activities are not always comparable only from an economic point of view. In our case, the dimensions were the herd size and the herd composition and they have nothing to do with economic valuation. The comparison between our clusters and the Eurostat farm typology is used as a verification of the correctness of our animals assemblages.

6.2.3. Classification of the cropping systems

We saw in the previous paragraph that animals assemblages could be partly related to the cropping system in place in a region and to the corresponding climate. Concerning the differentiation of LPS, the general approach in this document is to consider feeding strategy by comparing the regional livestock feed requirements to the local feedstuffs availability to decide of the level of feedstuff autonomy in a region (i.e. the level of dependence on the market for feedstuffs provision). For that – grazing requirements have been compared to fodders potential in a region and – monogastric requirements for digestible lysine have been compared to the potential lysine production from rich protein, pulses and grain cereals cultivated (see § - 4.2.3.). Independently of the animals requirements, the regional crops’ productions (area, yield) available within CAPRI have been used in a first step to determine the major cropping system existing in Europe. From all the 40 plant activities provided by CAPRI, the regional share per crop (soft wheat for instance), per gender (wheat = soft + durum wheat) or per family (cereals) has been calculated for each region. PCA was then performed on all the crops categories. If the main method was to remove crop categories presenting the highest correlations, some of the crop categories were selected (or removed) because of the possibility farmer has to use them directly as feedstuffs for one specific livestock sector. For instance “wheat” (durum + soft), “barley” and “grain maize” were preferred to “all cereals” category because their seeds can be used directly to feed poultry and in less extent porcine livestock.

Finally, eight cropping system descriptors were conserved:

- “Wheat” (durum + soft wheat)
- “Barley”
- “Fodder grasses”
- “Fodder Maize”
- “Rich protein oilseeds” (rape, soybean and sunflower)
- “Pulses”
- “Set-aside and fallow lands”
- Vegetables and permanent crops”

From these values, a range of clusters from 5 up to 11 has been tested and the final number of cropping systems was 8 (Figure 13). Averaged values of the descriptors per cluster are shown in annex 7. From this table and by using other ANOVA results from non retained descriptors, regional land use was described and clusters named. Voluntary, the different cropping systems identified have been sorted according to the presence of permanent crops: from permanent crops to annual crops. This should help the reader to progress inside the resulting classification.

- The "Permanent crops + vegetables" cluster corresponds to regions located on the Mediterranean border; Spanish, Portuguese, Italian and Greek regions are concerned. This trend is certainly closely related to the climate found in these regions: hot and dry, climate would limit the annual crops production to which permanent crops are preferred. When relating to livestock production (see §-6.2.2.), these regions receive OVINE-, GRANIVORES and OVINE/BOVINE-dominant livestock sectors. Pastoralism from one place to another, free-ranging grazing and the grazing of the common/natural grassland areas could be farming practices in vigour in these regions.
- The predominant "Fodder grasses" cluster presents a large share of the UAA occupied by permanent and temporally pastures. Located in Scotland and Ireland, around the Alpine massif in Austria and Italy or again in the Spanish Asturias and Cantabria regions, it corresponds to wet regions favoured by an oceanic or alpine climate. Regions are specialized in the grazing livestock production (figure 12); they are using grasslands as the main source of fibbers and fodder maize areas are very limited.
- The three following clusters "Fodder Grass > Maize", "Fodder Grass = Maize" and "Fodder Grass < Maize" correspond to the progressive increase of the fodder maize share in energy/fibbers supply. The corresponding regions are located around the previous "fodder grasses" regions and are progressively distant from these regions when the fodder maize share is increasing. "Fodder grass > maize" is located in the UK, around the Alpine massif and in medium mountainous regions such as the Corse, the Auvergne and Limousin regions in France or the Sardegna region in Italy. Then, "Fodder grass = maize" is expanded to less elevated regions situated in more diversified climatic zones such as Romanian, Polish, Lithuanian, Latvian or Swedish regions. Finally, when the grass/maize balance is inversed, "Fodder Maize > Grass" is spread over Europe and region such as the Anatoliki and Kentriki Makedonia region sin Greece, Lodzkie, Mazowieckie and Svietokzystie regions in Poland, Alsace, Bretagne and Pays de la Loire in France or others in Italy, the Netherlands, Germany and Belgium are identified as having a fodder maize-based feeding strategy for bovine but also porcine livestock sectors.
- The remaining three clusters are corresponding to cropping systems based on annual crops production plus at a lesser extent other fodders (root fodders), rich protein crops and fodder maize. They are located at medium latitude from northwest of France to eastern Poland, in the eastern part of the UK, In Bulgaria and Romania, in central Spain and in the Scandinavian Peninsula. These regions are not always matching a certain livestock sector (Figure 13). Only the "Mixed without SHGOAT" sector of central Europe seems to be correlated to the "Annuals + …" cropping systems, especially the "Annual crops + rich protein crops". All together, it seems that the diversified annual crops production is meeting the higher livestock sector diversity met in these regions and a general trend can be observed: "Granivores" or "Poultry" animals assemblages seem slightly correlated to the presence of diversified annual crops with protein and/or fodder maize cultivation which should be conceivable according to the importance of proteins into the granivores' ration.

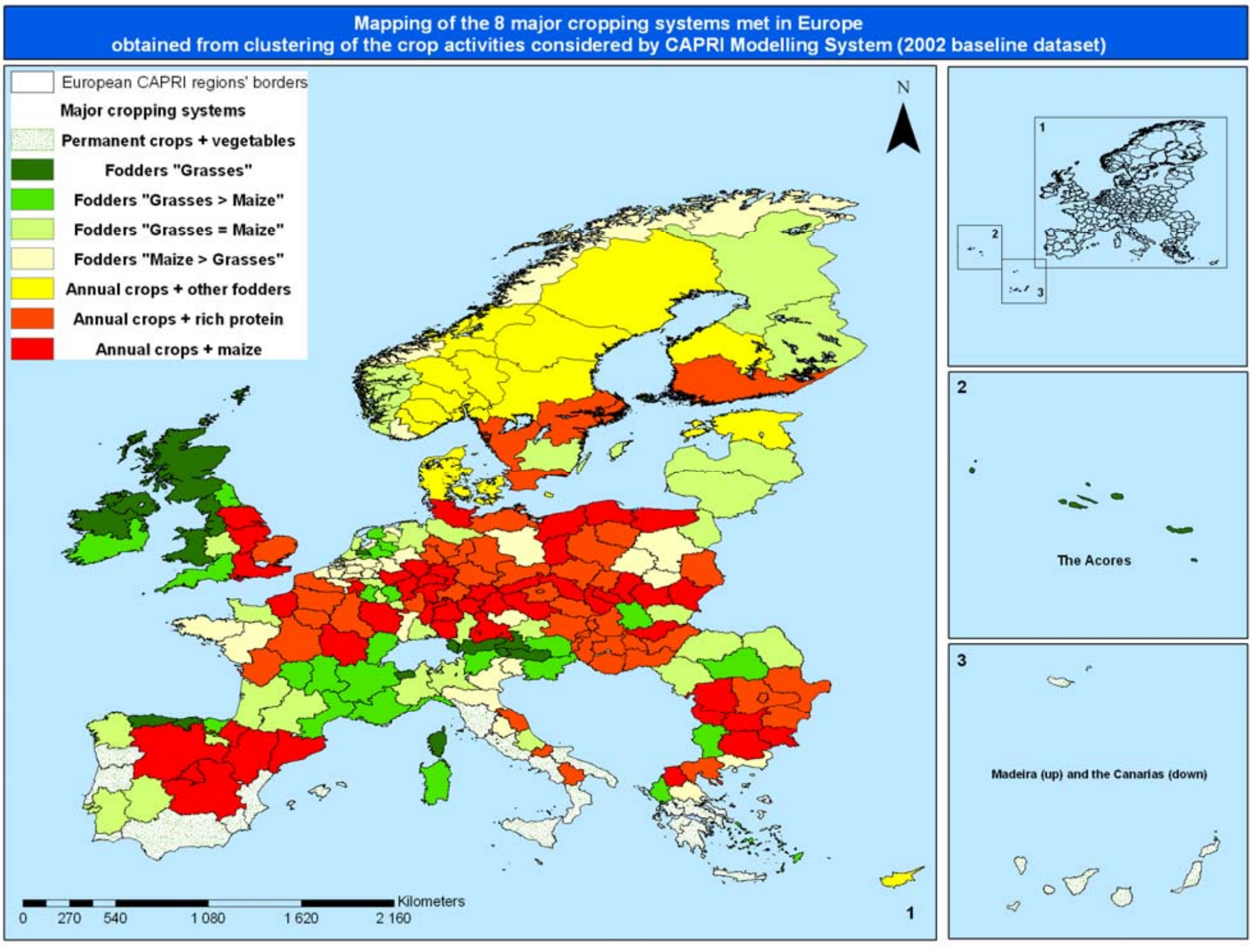

Figure 13: Mapping of the eight cropping systems identified over EU27 + Norway

6.2.4. Intermediary conclusions

Dimensions used until now to describe regions were broad and less informative for somebody who wants to address one particular livestock sector. However, the information obtained allowed us to figure out particularities of the regions and in less extent regional constraints and specificities of livestock production. From results obtained, we showed that decision to produce livestock, as any other agriculture activity, is partly governed by abiotic factors which define locally the potential land use. In most of the cases, for grazing livestock, cropping systems are strongly correlated to the climatic potential for biomass production from fodders itself influencing greatly the composition and the size of the grazing herd to rear in the region. At farm level as well as at larger scale (NUTS2), livestock production systems are partly consequences of the interaction between a local climatic potential – an adapted and effective local cropping system – a possible herd size and composition, the core of this tripartite relationship being the cropping system. It determines the potential of feedstuffs production and the level of autonomy to feed livestock herds. For instance, cattle's breeding is generally located in regions under the influence of oceanic and continental climates where the potential for fodders' biomass production is high to very high; this authorizes cost-effective breeding of large herds on well delimited permanent pasture parcels. At the opposite, limited fodder biomass production under Mediterranean climates requires adapted livestock such as goats and sheep's; in these regions the "cultivated" grassland areas being limited, the feeding strategy is based on grazing under permanent crops (olive trees, …), on common grasslands or on free-ranging grazing in mountainous alpages. However, feeding strategies is not only dependent on the local biomass potential. Part of the livestock requirements can be more or less fulfilled from marketed feedstuffs, especially proteins to feed granivores for which market costs remain very attractive.

Each one of the classifications performed previously gave us initial but insufficient knowledge to describe livestock production systems. If results suggested or even underlined relationships between climatic conditions, cropping system and animals assemblage in a region, integration of these three dimensions with other dimensions of production system must be conducted. It has been done by considering some of the previous descriptors when classifying livestock sectors and by using results of the cropping – animals assemblages to verify of the pertinence of the clusters obtained from the sector-specific classification.

7. Results from classification

This part of the document concerns the main results obtained from classification procedures applied to each one of the six livestock sectors identified within the GGELS project.

7.1. By-sector description of the diversity of the LPS

The 243 regions used by the CAPRI Modelling System have been early classified over (i) 10 animals assemblages and (ii) 8 major cropping systems. The results of these classifications would not be used directly as classifiers to class livestock production systems. On the other hand, cropping systems and animals assemblages together with Eurostat farm types will be used to describe and verify of the pertinence of the clusters obtained per livestock sector.

Concerning climatic clusters, they will be used *a posteriori* to split sector-specific LPS into several sub-lists corresponding to a LPS per climatic zone.

7.1.1. The BOMILK sector

Classification over the whole set of regions on BOMILK production has been performed from nine remaining significant variables describing more specifically this livestock sector. Among all, one variable was expressing the magnitude of the BOMILK production: the (BOMILK) herd size expressed in livestock unit. This variable was very strongly correlated (>0.95) to other quantitative variables such as total milk production, total manure or again total revenue and consequently only one was conserved – we choose the herd size because of it eases the interpretation. It was used in parallel of the relative participation of the BOMILK production to the total “livestock” revenue (%). The other seven descriptors are describing the feeding strategy adopted in region by focusing on the fodder activities. The share of the two main fodder activities (Grass and maize, as a percentage of the total UAA), the percentage of the total “plant production” revenue coming from the fodder activities or again the level of intensification (in €/LU and in % of the total BOMILK production costs) were considered. The pressure exercised by the BOMILK size onto the fodder activities was considered through the use of the stocking density (No. of grazing LU per hectare of fodder, all fodder activities) and by the potential autonomy (%) of a region to fulfilled energy requirements of grazing animals from all cultivated fodders in this region.

Results from PCA pointed out that BOMILK revenues was generally correlated with the level of intensification, suggesting positive relationship between the production and the magnitude of the investment spent for feedstuffs and veterinary products in the total cost of the BOMLIK production (Table 1). On the second component, negative relationship between the relative intensification and the level of autonomy for energy from fodder crops (but also protein, data not shown) suggested that the investment for feedstuffs and veterinary products are proportionally less important when fodder area is high; BOMILK systems based on fodder production have at a lesser extent recourse to market for feedstuffs supplying. If they are less subjected to market prices' fluctuations, they are on the other hand highly dependent of the climatic conditions; in this case, the choice of the climatic zone could be of high importance. From the third component it appears that the herd size can be largely increase when a higher part of the total UAA is cultivated with fodder maize. The larger and more constant yields observed for fodder maize (when compare to uncertain fodder grass yields) should allow producers to free they potential of BOMILK production of the grass production uncertainty. Finally, component 4 of the PCA which absorbed approximately 72% of the cumulated variability of the data pointed out the relatively less weighted effect of herd size; we can also underline that a low positive relationship exists between herd size, fodder maize share and the energy autonomy. This confirms the trend observed before: from a certain threshold, higher herd size is (economically) conceivable if sufficient auto-supplying of feedstuffs is planned on farm.

Table 1: Results of the PCA – Varimax rotation onto the nine descriptors retained for the BOMILK production description and clustering

	PCA comp. 1	PCA comp. 2	PCA comp. 3	PCA comp. 4	PCA comp. 5
Eigenvalue	2.12	1.85	1.55	1.00	0.77
Percent	23.54	20.59	17.22	11.13	8.56
Cum Percent	23.54	44.13	61.35	72.47	81.03
Eigenvectors (after rotation)					
Herd size (LU)	0.06	-0.03	0.14	**0.89**	0.12
Intensification (€/LU)	**0.72**	0.43	-0.08	-0.19	-0.15
Intensification (%)	0.01	**0.87**	-0.25	0.19	-0.10
Stocking density (LU/ha)	0.05	0.04	**0.93**	-0.04	-0.10
Revenues fodder (%)	**0.80**	-0.12	-0.02	-0.01	0.28
Revenues BOMILK (%)	**0.78**	-0.11	0.15	0.24	0.06
NRJ Autonomy (%)	0.07	**-0.80**	-0.24	0.37	-0.04
Fodder grass (%UAA)	0.15	-0.05	-0.10	0.11	**0.95**
Fodder maize (%UAA)	0.02	-0.14	**0.71**	0.43	-0.01

From this, clustering has been performed and 7 final clusters decided. To describe clusters particularities, analyse of variances of the nine retained descriptors was processed. The results of the ANOVA are summarized inside Annex 8.

Regarding the descriptors used for classification, an interpretation as objective as possible of the clusters was made by considering five main aspects of the BOMILK production for which several modalities each were defined:

- The importance of the BOMILK production in the region – 3 modalities from "subsidiary production" to "of primary importance" was interpreted from the BOMILK revenue (%) and the herd size (LU)
- The level of intensification of the BOMILK production – 3 modalities from "very intensive" to "extensive" was interpreted from intensification expressed in €/LU as well as in % and from the stocking density (LU/ha)
- A potential animal keeping strategy was proposed from the stocking density and the grass share in the total UAA (%) – 3 modalities "indoor", "outdoor" and "mixed"
- The feedstuff autonomy was interpreted from the autonomy for energy of grazing livestock from fodders, the stocking density, the intensification (% and €/LU) and the fodder revenue

(%). The objective was to decide of the level of dependence of a cluster to the marketed feedstuffs - 3 modalities were decided from “very dependent” to “independent”

- Finally we proposed to identify the main aliment composing the BOMILK ration from grass and maize share, the level of intensification (€/LU), the fodder revenues (%), the stocking density (LU/ha) or again the level of autonomy for energy.

Qualitative description of the seven BOMILK clusters identified is given within table 2.

Table 2: Qualitative description of the seven BOMILK clusters identified

Clusters	Production	Intensification	Keeping strategy	Market dependence	Main feedstuffs used
1	Subsidiary	Intensive	Indoor	Very dependent	Marketed
2	Secondary	Extensive	Mixed	Independent	Pasture / Maize
3	Primary	Extensive	Indoor	Dependent	Haymaking
4	Primary	Extensive	Outdoor	Independent	Pasture / grazing
5	Primary	Intensive	Mixed	Dependent	Pasture / maize
6	Subsidiary	Medium	Mixed	Dependent	Haymaking
7	Secondary	Intensive	Indoor	Dependent	Maize

To ease the interpretation of the clusters obtained for BOMILK, different analyses (of variances, contingency…) have been performed on the animals assemblage or on the farm types per BOMILK cluster. It helped to describe more consistently the BOMILK clusters.

- Cluster 1 concerned regions for which the BOMILK production is subsidiary meaning that other productions are dominant; the analyse of the animals assemblages present in this cluster pointed out that granivores and ovine productions was of primary interest. When producing milk from cattle, the regions concerned are practicing very intensive BOMILK production from dairy cattle’s housed and fed with marketed feedstuffs. The limited share of fodders and especially of fodder grasses indicated that the manures from dairy cattle could be sprayed on annual or permanent crops rather than on pastures. Or at least that pastures when exist are sprayed with manures from other livestock activity than the BOMILK activity. The regions are Mediterranean regions generally corresponding to Mediterranean islands: Malta, Cyprus, Madeira (Portugal) and the Canarias (Spain). The main farm types representing in this cluster are T44 – SHGOAT, T50 – Granivores and T82 – Crops + livestock. All together the BOMILK production in these regions appears as a second income production for diversification of the sources of incomes and for the limitation of the effects of failure of any other main activities (here, ovine and granivores for livestock production). This cluster has been called <u>“Mediterranean intensive BOMILK”</u>.

- Cluster 2 corresponded to regions for which the BOMILK production is not considered as of primary importance due to the fact that other livestock activities are conducted in parallel and are sources of at least the same proportion of incomes. Approximately two third of the regions had another grazing activity such as BOMEAT or/and SHGOAT activities; the remaining one third were often dedicated to POULTRY production. This trend was confirmed when analysing the main farm types represented in this cluster. T41 – cattle dairy, T42 cattle fattening, T44 – SHGOAT, T81 – crops + grazing and T82 – crops + livestock are the most represented farm types. All together, BOMILK production is considered as a natural complement to other grazing livestock activities in place in these regions. The number of regions in this cluster is the highest (n=65) and a large range of countries are concerned. However most of them are localised at medium or high latitudes. Only few regions are identified in Italy, two in Portugal and several in Romania. The majority are situated in the Scandinavian Peninsula, in Latvia, Estonia and Slovakia or again in France (10), in Germany, Austria, Check Republic and Hungary. These regions are corresponding to oceanic or continental climates. Very low revenue from fodder activities together with a relatively low herd size and a medium to high fodder grass share of the total UAA suggested an outdoor keeping strategy with a high utilization of the biomass produced on farm. Furthermore, stocking density is relatively low suggesting an extensive use of the fodder area. However, because of a more limited duration of the grazing period on pasture, the feeding strategy is based on a mixed of pasture grazing and fodder maize supplies during winter period. The denomination proposed for this cluster refers to the complementarity between other grazing activities and the BOMILK production: "Grazing BOMILK complement".

- For the third cluster, BOMILK production became of primary importance for the total revenue of the regions (n=32). With a medium herd size, these regions have large fodder grass areas at their disposal; but an important fodder revenue (mainly from grass) signified that fodder production could be also considered as a product of high interest. We proposed two assumptions: (i) part of the fodder production is sold and not directly used in the region; producers are preferring to have recourse partly to marketed feedstuffs such as rich protein feedstuffs to feed the animals – (ii) despite large grass areas, the biomass production or its exploitation by BOMILK animals could be too short because of climatic reasons. Almost all the regions concerned are located in the Scandinavian Peninsula (Norway, all regions in Finland, Sweden) or in high or medium mountain regions for Italy (Trentino Alto-Adige, Val d'Aosta regions) for Austria (Tyrol region) or for Spain (Pais Vasco, Cantabria and Asturias regions); so, they are under the influence of cold continental, alpine or even artic climates in elevated zones of Europe. Consequently the second option seems to be more relevant: BOMILK production is an essential source of income for holdings situated in less favoured areas for which the potential window to keep animals outdoor is limited by the climatic characteristics met. During winter period, animals housed are then fed with hay (explaining the high revenue share of fodder activities) and marketed feedstuffs (high intensification). For all these reasons, cluster 3 has been denominated "Climate constrained BOMILK".
- Concerning cluster 4, regions for which BOMILK revenue is of primary importance presented very important area of grasslands and almost no fodder maize area. The level of autonomy for energy is very high (generally covering the all energy and protein grazing livestock requirements) and the recourse to marketed feedstuffs is nearly null. Feeding strategy of these regions appeared as fodder grass-based and presented and low stocking density. All together, these results clearly indicate an extensive BOMILK production. When considering the animals assemblages, other livestock activities such as poultry and SHGOAT activities (T44 – SHGOAT) are complementing the dominant dairy activity. The regions concerned are located in only two european countries: Ireland and the UK. This cluster has been denominated "Extensive grass BOMILK "production.
- As well as the two previous clusters, BOMILK activity is of first importance and even preponderant for most of the regions. But the major difference is that the feeding strategy in place in the 60 regions concerned is based on a mixed utilization of grass and maize fodder. The dual utilization of grass and maize allows regions to breed large size BOMILK herds at medium to high stocking density. But it asks for the utilization for part of feedstuffs from the market. As a consequence, the BOMILK production in these regions is very intensive based on a mixed keeping strategy. More than 80% of these regions are corresponding to "bovine" and "mixed without SHGOAT" animals assemblages. In parallel, the two major farm types represented in this cluster are T41 – "cattle dairy" and T44 – "SHGOAT + other grazing". The corresponding regions are located in Italy (Lombardia, Piemonte, Emilia Romagna, and Veneto

regions), in France (Franche Conté, Pays de la Loire, Bretagne, Lorraine, the two Normandie or again the Auvergne regions), in Poland and in the Netherlands. It concerns also Lithuania, the Duché of Luxemburg and almost all the German regions. These regions are often identified as the main nitrate-phosphorus polluted regions from livestock activities in Europe. The denomination of this cluster is consequently "Intensive grass+maize BOMILK" production.

- With a very low share of fodder areas, a medium autonomy for energy supply from fodders and a low stocking density, BOMILK production in cluster 6 is considered as subsidiary. The size of the BOMILK herd is generally limited and the majority of the animals present in the regions are granivores or ovine livestock units. The major difference with the first cluster described above is that the BOMILK production is not considered as an assurance in case of failure of the other livestock activities; then, despite the fact that feedstuffs and veterinary products represent a very large proportion of the BOMILK production costs, the amount invested for the BOMILK production remains very limited. All together, limited grass (maize) areas and limited feedstuffs investment are describing situation where feeding of BOMILK could be undertaken from other sources of biomass. Moreover, the fact of the main countries concerned are Spain, Greece, Bulgary, Poland, Italy or again Portugal could correspond to feeding practices inherited from local cultures where the free-ranging of animal on common grassland areas is currently practiced. As said below, granivores and ovine are dominant activities in these regions. Consequently we assumed that BOMILK production in these regions is still considered as a subsistence production. For this reason, the denomination given to the cluster 6 is "Free-ranging subsistence BOMILK" production.
- Finally, cluster 7 depicts regions for which the BOMILK production is perceived as of primary importance. With medium to high herd size and very important stocking density, we assumed that the BOMILK are indoor kept. Beside this, fodder grass share is limited when the share of fodder maize in the total UAA is the highest we observed. With a relatively low to medium intensification (proportion of the feedstuffs and veterinary products investments in the total cost of the BOMILK production) level, the regions are basing their entire feeding strategy on the fodder maize production. They are nearly independent for feeding thanks to high energy autonomy obtained from maize. This feeding strategy should allow intensive BOMILK production at the condition that climatic conditions are very constant and favourable to maize growth. The regions identified in this cluster are corresponding to four regions in the Netherlands, almost all the Belgium regions and the Muenster region in Germany. They are benefiting of an oceanic temperate climate relatively favourable to green-fodder maize production. These regions are presenting granivores as major other possible animals assemblages. In accordance with denomination given to cluster 5, cluster 7 has been called "Intensive maize BOMILK" production.

Diversity of the BOMILK production systems in EU27 + Norway has been mapped to ease the visualisation of its spatial distribution (Figure 14). Later in paragraph §-7, the results of the classification of the BOMILK production systems will be confronted to results of the climatic and cropping systems' classifications to point out the number of sub-levels to be considered when deciding of the sampling effort for the survey addressing diversity of the manures management practices.

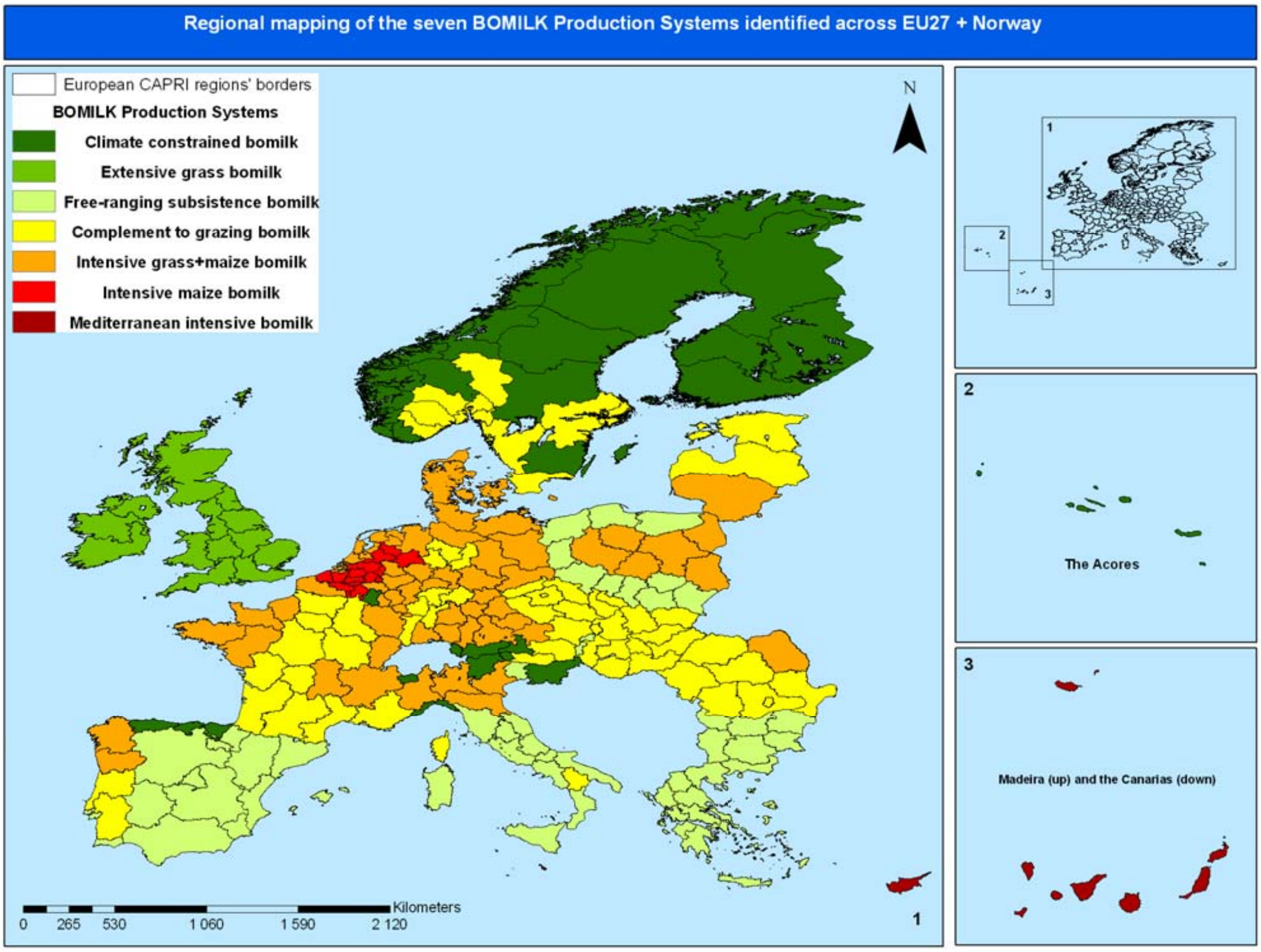

Figure 14: Diversity of the BOMILK Production Systems in EU27 + Norway

7.1.2. The BOMEAT sector

Classification over the whole set of regions for BOMEAT production has been performed from eight remaining significant variables describing more specifically feeding strategy related to the cropping system , the BOMEAT productivity and the level of intensification livestock sector. Among all, one variable was expressing the magnitude of the BOMEAT production: the (BOMEAT) revenue which was strongly correlated (>0.95) to the herd size or again manure production (result not shown). Others variables used were: the BOMEAT intensification level (€/LU) describing the investments made to provide feedstuffs and veterinary products to one BOMEAT livestock unit – the stocking density (LU/ha) calculated from the total fodders area – the fodder revenues (as a percentage of the total plant production revenue) and the share (%) in the total crop area of grass fodder and maize fodder were considered to described the cropping system and the main source of energy for BOMEAT – the later was used in parallel of the level of autonomy (%) for energy from all available fodders in a region – finally, to consider the importance of the BOMEAT herd size in the total number of livestock unit in a region, the percentage (%) of livestock units belonging to BOMET has been taken into account .

Results from PCA pointed out that the stocking density is strongly related to the proportion of fodder maize cultivated suggesting that the BOMEAT production depends highly of this fodder activity (Table 3). But feeding of BOMEAT depend also on the fodder grass production: the BOMEAT revenue as a percentage of the total livestock revenue in a region is correlated to the share (%) of fodder grass cultivated suggesting that fodder grass participates actively to the feeding strategy and/or the keeping strategy for a large range of regions in Europe. This is confirmed by the positive relationship existing between the revenues (%) of the BOMEAT activity and the revenue (%) of the fodders activity. When limited due to diverse reasons, the production of fodders is partly compensated by the utilisation of marketed feedstuffs as described by the negative relationship existing between the level of autonomy for energy and the level of intensification. Thus, the total revenue of the BOMEAT activity could increase in parallel of the level of energy autonomy as suggested by the fourth component of the PCA. From these first observations, it seems that feeding strategy and energy and protein autonomy from fodder activities is the key to produce BOMEAT in a region; effort has been made to interpret the BOMEAT diversity in EU27+Norway by considering this particular dimension of the production system.

Table 3: Results of the PCA – Varimax rotation onto the eight descriptors retained for the BOMEAT production description and clustering

	PCA comp. 1	PCA comp. 2	PCA comp. 3	PCA comp. 4
Eigenvalue	2.015	1.698	1.407	0.863
Percent	25.188	21.230	17.584	10.789
Cum Percent	25.188	46.418	64.002	74.790
Eigenvectors after rotation				
Intensification (€/LU)	-0.094	0.0589	0.910	0.059
Stocking density (LU/ha)	0.897	-0.033	0.127	0.001
Fodders revenue (% of total)	0.077	0.722	0.295	0.148
BOMEAT revenue (€)	0.183	0.0151	-0.039	0.805
Energy autonomy (%)	-0.058	0.074	-0.596	0.571
BOMEAT herd size (% of total LU)	-0.089	0.533	0.188	0.648
Fodder grass (%UAA)	-0.067	0.826	-0.285	0.003
Fodder maize (%UAA)	0.853	0.021	-0.218	0.131

Clustering has been performed and 6 final clusters decided to describe the diversity of the BOMEAT production. To describe clusters particularities, analyse of variances of the eight retained descriptors was processed. The results of the ANOVA are summarized inside annex 9.

Regarding the descriptors used for classification, an interpretation as objective as possible of the clusters was made by considering five main aspects of the BOMEAT activity for which several modalities each were defined:

- The importance of the BOMEAT activity as a source of income in a region – 3 modalities from "subsidiary production" to "of primary importance" was interpreted from the BOMILK revenue (%) and the herd size (LU) – 3 modalities from "subsidiary to "of primary importance"
- The level of pressure exerted onto the grass area from the revenue of BOMEAT coupled with the stocking density and the fodder maize share (%) – 3 modalities from "low" to "high"
- The feedstuff autonomy was interpreted from the autonomy for energy of grazing livestock from fodders, the level of intensification (€/LU) and the fodder revenue (%). The objective was to decide of the level of dependence of a cluster to the marketed feedstuffs - 3 modalities were decided from "very dependent" to "independent"
- A potential animal keeping strategy was proposed from the stocking density, the fodder revenue (%) and the grass share in the total UAA (%) and by taking into account the other grazing activities in competition for pastures' occupation – 3 modalities "indoor", "outdoor" and "mixed" were proposed

- Finally we proposed to identify the main aliment composing the BOMEAT ration from grass and maize share, the level of intensification (€/LU) and the fodder revenues (%).

Qualitative description of the seven BOMEAT clusters identified is given within table 4.

Table 4: Qualitative description of the six BOMEAT clusters identified

Clusters	Importance	Pressure on grassland	Market dependence	Keeping strategy	Main feedstuffs used
1	Secondary	Low	Very dependent	Indoor	Grass - Market
2	Primary	Medium	Dependent	Mixed	Grass - Maize
3	Secondary	Low	Independent	Mixed	Maize
4	Secondary	High	Dependent	Indoor	Maize
5	Subsidiary	Medium	Very dependent	Mixed	Market
6	Subsidiary	Low	Dependent	Outdoor	Market

To ease the interpretation of the clusters obtained for BOMEAT, different analyses (of variances, correspondence …) have been performed on the animals assemblage or on the farm types per BOMILK cluster. It helped to describe more consistently the BOMEAT clusters observed.

- Cluster 1 concerned regions for which the BOMEAT production is a second order livestock activity. The main animals assemblages other than "bovine" corresponded to poultry assemblages and at less extent to ovine / bovine assemblage. The main farm types observed in this clusters are those dealing with cattle productions (T41, T42) and the T44 – "SHGOAT +other grazing". The BOMEAT activity is generally based on a cropping system where fodder grass share is higher or at least equal to the fodder maize share. However, because BOMEAT activity is not of primary importance, the grassland area could be reserved for other grazing production such as the dairy or ovine production. Indeed, despite a relatively low pressure on grassland and a low stocking density, the dependence to marketed feedstuffs remains very high. Consequently BOMEAT animals could be housed rather than outdoor kept. But in the same time, the availability of relatively important area should allow producers to fulfil part of the BOMEAT feed requirement from fodder grass, the rest being provided by the market. The main countries concerned by this BOMEAT production system are Italy, Germany, Romania, Greece, Slovakia, Portugal, Norway, Austria, and Spain. For all these reasons, cluster 1 was called "complement to ovine BOMEAT".
- The BOMEAT activity is of primary importance for the second cluster identified. Due to important area of grass but a medium stocking density, keeping strategy is mixed and the feeding strategy is based on the utilisation of fodder grass as well as of fodder maize. The BOMEAT ration is then completed with feedstuffs from the market. This cluster corresponded to an intensive BOMEAT production system. The major farm types are those corresponding to the production of "cattle for fattening and rearing" (T42), dairy cattle (T41) and "SHGOAT + other grazing" (T44). Consequently these regions are specialized in the production of cattle and at less extent of ovine; the animals assemblages indicated that grazing animals are preferred to others in these regions. Related cropping systems is essentially composed of the four "grass" cropping systems identified; fodder maize is also of interest and contribute at significant level to the feeding strategy. The main regions are situated in France, in the north of Italy, in the UK (North West, South West and Wales regions), in Spain (Castilla-Leon, Extremadura and Andalucía regions) and the two Irish regions. The cluster 2 has been denominated "Intensive grass maize BOMEAT".
- Concerning cluster 3, the BOMEAT activity is of secondary importance and is generally dominated by granivores (porcine especially) production. Farm types corresponding to the

granivores activities (T50 and T72) represented more than 30% of the total number of farms belonging to this cluster. The feeding strategy relied on the use of a large part of fodder maize in the ration together with fodder grass. But another important source of protein and energy could be supplied from the rich-protein and annual crops composing around 90% of the cropping systems corresponding. As a consequence, the dependence to the market for feedstuffs provision is very low. Considering that the other livestock activities are indoor productions and that dairy cattle's are scarce, we can assume that the entire area of grass is available for BOMEAT animals. However, the level of dependence suggests that the fodder grass is used for haymaking rather than for grazing and BOMEAT animals keeping should correspond to a mixed strategy. It concerns a relatively low number of countries amongst them the Check Republic, Hungary, half of Slovakia, the northern and eastern regions of the UK plus the Burgenland region in Austria. It has been called "complement to porcine BOMEAT".

- Together with a relatively high level of autonomy for energy, the high dependence to market for feedstuffs provision and a feeding strategy based on the utilisation of fodder maize rather than fodder grass indicated that cluster 4 is an intensive BOMEAT production system. In the same time, a reduced area of fodder grass restricted the animals movement and suggested a indoor keeping strategy. On the other hand BOMEAT production is perceived as a secondary source of income for the corresponding regions. "Dairy cattle" (T41) and "SHGOAT + other grazing" (T44) represented more than 50% of the total number of farms belonging to this cluster. As for cluster 2, the animals assemblages indicated that grazing animals are preferred to other types of animals in these regions. Finally, clusters 2 and 4 are relatively similar but they differed essentially because of the feeding strategy and of the related cropping systems in use; cluster 4 is fodder maize-based intensive system. It was consequently denominated "Intensive maize BOMEAT". It corresponds to regions grouped in the part of Europe: in Belgium, the Netherlands, Denmark, Luxemburg, France and in Germany. We can also indicate that Malta, Cyprus and the Canarias in Spain are belonging to this cluster.
- Cluster 5 is very particular. With limited area of fodder grass and maize, and consequently a very high level of dependence to the market for feedstuffs provision, this cluster appeared disadvantages. On the other hand, the share of revenue coming from the fodder activities is very important suggesting that the production of fodder is mainly destined to the market rather than to be auto consumed on farm. Together with the medium share of fodder grass area this suggested that fodders cultivated are different and may correspond to root fodders or others. From this we also assumed that extreme climatic conditions could explain the subsidiary importance of the BOMEAT production and the relatively limited production of traditional (grass and maize) fodders. The major (>70%) farm types in these regions corresponded to dairy cattle (T41) and SHGOAT + other grazing (T44) and the main animals assemblages were the "bovine" and "grazing" assemblages. In these regions production of cattle for milk and of ovine is preferred to the meat production from cattle. The corresponding regions are located in Sweden, Norway and Finland; this confirming our assumptions. It has been called "Subsidiary Nordic BOMEAT".
- The last cluster (n°6) corresponded to regions where the BOMEAT production is considered as subsidiary. The limited amount of energy and protein available to fulfil the BOMEAT animals' requirements was explained by very limited area of fodder grass and maize. The cropping systems in place are mainly constituted from annual and permanent crops (>75%). Due to the low availability of fodder energy and fibbers, the feeding strategy is mainly based on the provision of marketed feedstuffs in the ration and the fodder revenue is almost inexistent. Beside this, the corresponding revenue being very low, BOMEAT activity is considered as subsidiary. Other activities such as ovine (T44) and granivores (T50, T72) productions are

preferred to the BOMEAT activity; in parallel the land use and occupation are preferentially reserved to the annual and permanent crops rather than to pasture or fodders production. As for cluster 5, we assumed that regions concerned are located in extreme climatic conditions limiting the potential biomass production of grasslands and asking for the breeding of smallest grazing livestock (ovine) or indoor livestock activity (granivores). The regions concerned are most of the regions in Greece, Spain and Bulgaria; surprisingly, it concerned almost all the regions in Poland too. A deeper consideration of the Polish situations showed us that the cropping system was very particular in the regions (high proportion of annual and permanent crops); together with a limited herd size, it explained why polish regions were considered together with other Mediterranean regions. To refer to cluster 5 and to consider that, apart from Poland, the regions concerned are located in the climatic extreme Mediterranean zone, this cluster has been called <u>"Subsidiary Mediterranean BOMEAT"</u>.

Diversity of the BOMEAT production systems in EU27 + Norway has been mapped to ease the visualisation of its spatial distribution (Figure 15). Later in paragraph §-7, the results of the classification of the BOMEAT production systems will be confronted to results of the climatic and cropping systems' classifications to point out the number of sub-levels to be considered when deciding of the sampling effort for the survey addressing diversity of the manures management practices.

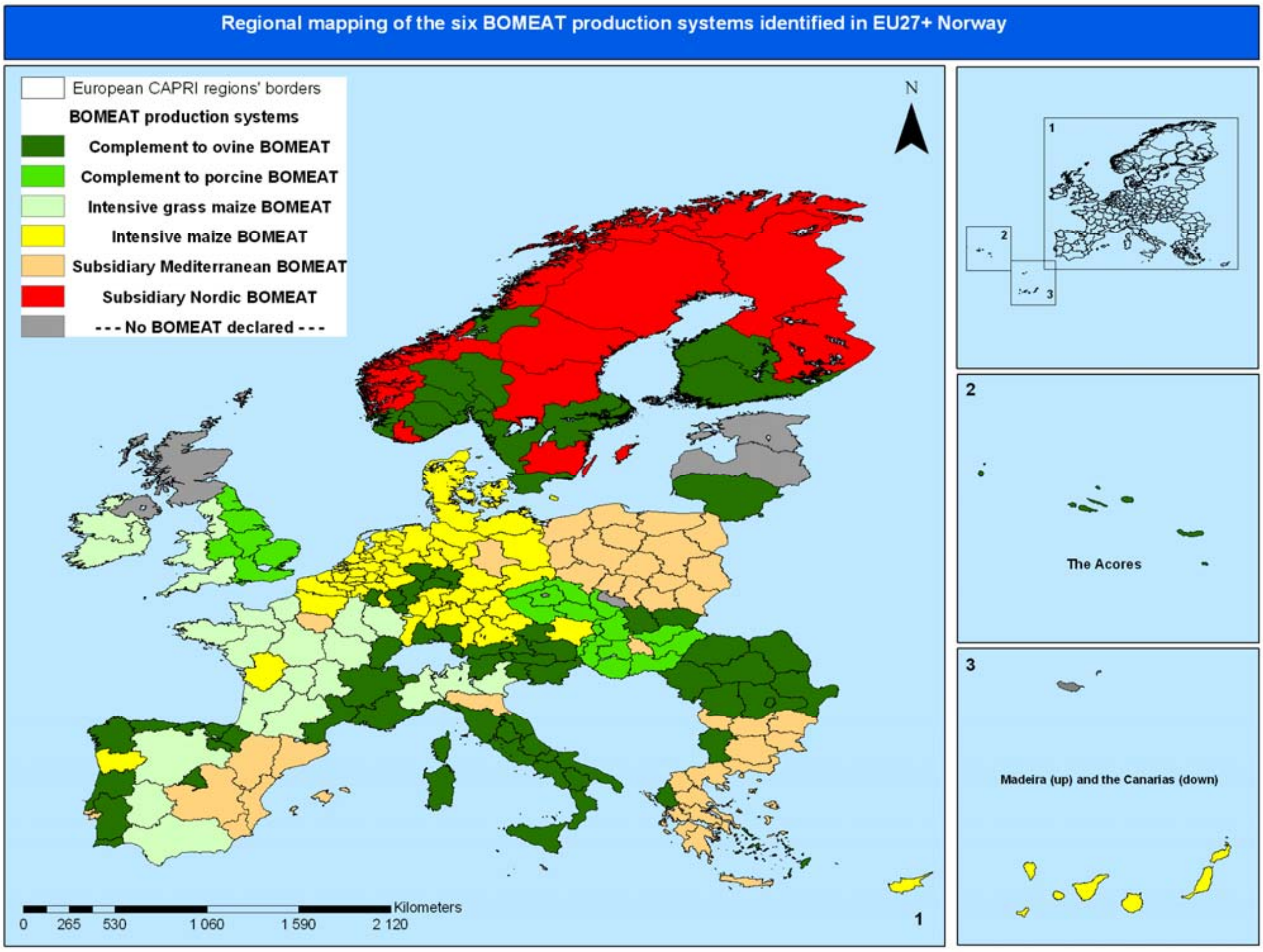

Figure 15: Diversity of the BOMEAT Production Systems in EU27 + Norway

7.1.3. The SHGOAT sector

Classification over the whole set of regions for SHGOAT production has been performed from seven remaining significant variables describing more specifically feeding strategy related to the cropping system , the SHGOAT level of productivity and the level of intensification. Among all, one variable was expressing the magnitude of the SHGOAT production: the (SHGOAT) revenue which was strongly correlated (>0.95) to the herd size or again manure production (result not shown). Others variables used were the SHGOAT herd size as a percentage of the total number of livestock units, the share (%) in area of the fodder grass over the total UAA, the intensification level (% of the total SHGOAT production costs) describing the investments made to provide feedstuffs and veterinary products to one SHGOAT livestock unit – the stocking density (LU/ha) calculated from the total fodders area – the fodder revenues (as a percentage of the total plant production revenue) and the level of autonomy (%) for energy from all available fodders in a region.

Results from PCA pointed out that SHGOAT revenue is strongly correlated to the share of the SHGOAT herd in the total number of livestock units in a region (Table 5); these two descriptors will be used later to address the importance of the SHGOAT activity in a region (from subsidiary to of primary importance).

Table 5: Results of the PCA – Varimax rotation onto the seven descriptors retained for the SHGOAT production description and clustering

	PCA comp. 1	PCA comp. 2	PCA comp. 3	PCA comp. 4
Eigenvalue	1.737	1.539	1.241	0.941
Percent	24.808	21.986	17.731	13.437
Cum Percent	24.808	46.794	64.525	77.962
Eigenvectors after rotation				
Stocking density (LU/ha)	-0.134	-0.011	-0.022	0.953
Energy autonomy (%)	-0.236	-0.671	0.217	-0.412
Fodder grass (%of total UAA)	0.278	-0.273	0.745	-0.070
Intensification (%)	-0.004	0.890	0.084	-0.136
SHGOAT revenues (€)	0.842	-0.095	0.007	-0.025
Herd size (% of LU tot)	0.814	0.283	-0.019	-0.109
Fodders revenues (%)	-0.24	0.197	0.842	-0.003

Not surprisingly, we observed a strong negative relationship between the level of autonomy for energy and the level of intensification; together with the fodder revenue, these two descriptors will be used to determine the level of dependence of the SHGOAT activity to the market for provision of feedstuffs (from independent to very dependent). The fodder grass share (%) in the total crops area will be used together with the stocking density and the level of intensification to propose a possible feeding strategy (3 modalities: grass, market, common grasslands); but it has to be weighted by the animals assemblages before to statute on the destination of the fodder grass to SHGOAT or to any other grazing animals. The level of intensification of the SHGOAT production will be confronted with the stocking density to determine the level of intensity (from extensive to very intensive) of the livestock production activity as an indicator of the pressure applied on grassland. Finally, despite the lack of information, from all the dimensions considered we tried to propose a keeping system (4 modalities: indoor, mixed, outdoor and free ranging).

Clustering has been performed and 6 final clusters decided to describe the diversity of the SHGOAT production systems. To describe clusters particularities, analyse of variances of the seven retained descriptors was processed. The results of the ANOVA are summarized inside annex 10.

At the opposite of the BOMILK and BOMEAT activities, SHGOAT production systems were more difficult to describe; the qualitative description of the six production systems identified involved a more subjective interpretation of the results, especially when describing possible keeping strategies. To avoid confusion and inconsistency with the reality, we performed supplementary analyses to describe as precisely as possible the clusters particularities. The qualitative description has been done in two steps: first, we proposed modalities from the sole results of the ANOVA on the seven descriptors, second, after analyses of contingence and ANOVA on variables not already used (cropping systems, animals assemblages, farm types or again SHGOAT for fattening carcass weight), the modalities have been reviewed. The final qualitative description of the SHGOAT production systems is summarized within table 6.

Table 6: Qualitative description of the six SHGOAT clusters identified

Clusters	Activity importance	Intensity	Market dependence	Feeding strategy	Keeping strategy (*as a proposition*)
1	Subsidiary	Intensive	Independent	Hays + fodders	Indoor
2	Primary	Extensive	Independent	Common grassland	Outdoor
3	Primary(shared)	Intensive	Dependent	Market + grass	Indoor
4	Subsidiary	Intensive	Very dependent	Market	Indoor
5	Subsidiary	Intensive	Dependent	Market + grass	Indoor
6	Subsidiary	Intensive	Dependent	Market + grass	Outdoor

- Cluster 1 corresponded to a production system where the revenue of the SHGOAT activity is not predominant and can be considered as subsidiary; Major farm types in this cluster are “dairy cattle” (T41, >75th) and “SHGOAT + other grazing” (T44; >50th). This was confirmed by the analyse of contingence from the animals assemblages: only four animals assemblages composed the cluster and corresponded to bovine and/or ovine activities; the granivores activities were totally absent. To perform bovine (predominant) and ovine (subsidiary) production, the cropping system of cluster 1 is composed at 50% of “fodder maize” and 40% of “cereals + other fodders” describing regions of intensive milk production where diversification is based on an ovine activity. The potential of energy/protein and fibbers production from the corresponding crops suggested a SHGOAT feeding strategy not requiring marketed feedstuffs; the SHGOAT animals could be potentially kept indoor if ration is based on haymaking and fodder supplementation or partially outdoor if grazing is not limited; this determined the “mixed” keeping strategy proposed. However, fodder grass area being very restrained, we finally proposed an “indoor” keeping strategy. From the same set of observations (limited fodder grass areas, fodder maize dominance for dairy cattle) we also thought that the dairy cattle in these regions is certainly intensive-indoor, so could be the SHGOAT production system. To verify this assumption, we analysed separately the level of intensification expressed in €/LU and we found that cluster 1 presented the highest investment for feedstuffs and veterinary products.

  For this cluster, large share of annual crops and high use of fodder maize suggested a constrained situation where BOMILK and SHGOAT production system could be climatic- or market-driven. The list of the regions was then analysed and the corresponding regions were all located in the Scandinavian Peninsula: in Norway and Sweden (Finland was not represented due to the fact that 4 over 5 regions did not present a SHGOAT activity declared in 2002). It tended to confirm a climatic-driven constraint; however, herd size is very limited and we could imagine a market-driven system dedicated to the production of niche market products at high added value. The denomination having to express the particularities identified, the SHGOAT production system has been called “Complement to dairy cattle Nordic SHGOAT”.

- Cluster 2 corresponded the traditional image one could have of the SHGOAT production: of primary importance (with the highest herd size observed), the corresponding SHGOAT production system is based on a low share of fodder grass (declared area), a very low proportion of the revenue coming from fodders activities and a low dependence (in % and even more in €/LU) to the market for feedstuffs provision. All these particularities suggested a very specialized but not intensive ovine production in region. This was confirmed first by the high proportion (around 50% of the total farms) of T44 “SHGOAT + other grazing” and T71 “mixed grazing” and second by the very low proportion of the other cattle- and poultry-specialised farm types T41, T42 and T43. Proportions of “crops + …” (T81 and T82) were also significant describing situation were farms are generally diversified. Not surprisingly, when analysing animals assemblages composition of the cluster, “ovine-poultry (47%) and “ovine-bovine” (37%) were the two main animals assemblages identified. In parallel, the main cropping system in place corresponded to vegetable and permanent crops (45%) followed by “cereals + other fodders”. This type of cropping system is describing climatic-restrained Mediterranean situation where fodder grass and maize production are very limited by the water deficit; it strongly influences the feeding strategy by having frequently recourse to the grazing of common grasslands (free-ranging on common areas) and/or of grasslands under permanent crops (owners’ areas). From all, cluster 2 has been called “Mediterranean free-ranging SHGOAT”.
- The SHGAOT activity inside cluster 3 was embedded inside the “Ovine/bovine” and “Grazing” animals assemblages. In parallel, the regions were characterized by a high diversity of animals assemblages: “granivores”, “bovine”, “mixed without SHGOAT” and “poultry” were all present. But none of the six animal assemblages observed was dominant. As any other livestock activities, SHGOAT was then considered of primary importance. If T44 “SHGOAT + other grazing” was the only one farm type present at more than the 75th percentile, we observed other farm types such as dairy cattle (T41), “cattle for fattening” (T42), “Granivores” (T50) and “mixed granivores” (T72) at 50th percentile; this confirmed the high level of diversification of the livestock production in these regions and the preponderance (55%) of the livestock activities in the total agriculture revenue.

  In parallel, cropping systems in place were also diverse but almost all corresponded to fodder grass and maize mix at different ratio each. The related regions are consequently regions where fodder activities are of primary importance for livestock feeding using fodder maize and from fodder grass (for haymaking as well as for direct grazing). From the cropping systems diversity, we also suspected relatively constant climatic conditions (water precipitation and temperature) favourable to the cultivation of fodder grass and maize; continental or oceanic climates could correspond. Effectively, all the regions are located in two single countries at medium latitudes under the influence of an oceanic temperate climate: the UK and the Netherlands. Because of the presence of numerous (grazing) livestock activities, stocking density appeared as high (around 1.4) and grazing pressure on the fodder grass areas should be high. Then, to perform the fodder grass biomass use, haymaking and green silage should be frequent practices. Together with a relatively high level dependence to the market for feedstuffs provision, the use of green silage indicated an intensive feeding strategy and suggested an indoor keeping strategy.

  All together, the characteristics listed hereinbefore suggested a “temperate intensive indoor SHGOAT” production system.

- Cluster 4 grouped together a large part (45%) of the regions to be considered when classifying the SHGOAT activities in EU27 + Norway. For all the 101 regions belonging to this cluster, the SHGOAT production was considered as subsidiary the majority of the UAA being used for annual cereals and rich protein crops, permanent crops and in less extent other fodders than grass and maize (73% in total). Mostly dedicated to the plant activities, it was logical to observe a total revenue form livestock activities not exceeding 40% (as for cluster 2) of the total agriculture revenue. On the other hand, when reared, SHGOAT animals are fed essentially with marketed feedstuffs; around 70% of the investments for SHGOAT activities concerned the supplying of feedstuffs and veterinary products (551 €.LU^{-1}.$year^{-1}$, fourth position). This explained partly the fact that despite small herd size, the total milk production was of medium magnitude requiring relatively high yearly yield of milk per animal. The cluster 4 was then declared as of intensive level of production. Together with the restricted areas of fodder grass, it suggested an indoor keeping strategy. Another aspect concerned the animals assemblages: cluster 4 grouped regions for which "poultry", "granivores" and "granivores/ovine" represented more than 55% of the total livestock units. Thus, SHGOAT was in most cases perceived as a complement to granivores (monogastric) production activities. It has been consequently denominated "complement to granivores intensive SHGOAT". The number of regions being huge, readers should refer to the figure 16 to visualise the regions concerned.
- Cluster 5 was very particular in this sense that it was composed at more than 85% of animals assemblages corresponding to "granivores" (21%) and "bovine" (64%) activities. Holdings specialized in the breeding of cattle and pigs were dominant: a very significant part of the cattle activities corresponded to dairy cattle (T41) and dairy cattle rearing (T43); T50 "granivores" and T72 "granivores + other grazing" were completing the farm types' profile of this cluster. As for the previous cluster, cereals, rich protein and fodder maize occupied a large part of the total UAA (around 65%) and suggested that the dependence to the market for feeding provision is high due to very limited fodder grass availability. On the other hand, the presence of large dairy cattle herd suggested a high competition for pasture grazing as well as for fodder maize consumption; SHGOAT being of subsidiary importance and stocking density being the highest one between clusters, the fodder grass and maize should be principally destined to dairy cattle rather to ovine herds. Consequently, SHGOAT was a complementary activity kept indoor and fed with marketed feedstuffs. The yields of the SHGOAT activities were medium-to-high depicting an intensive milk and meat production. Al together, the characteristics allowed us to denominate cluster 5 "complement to bovine intensive SHGOAT". The number of regions being huge, readers should refer to the figure 16 to visualise the regions concerned.
- Finally, cluster 6 was composed of the 21 remaining regions for which SHGOAT was perceived as a subsidiary production to the bovine activities (90% of the animals assemblage profile). The livestock activities were sustained by crop systems where fodder maize and fodder grass represented more than 90% of the land use; this could be considered as fodder monoculture. Consequently, the corresponding regions were very specialized in cattle production. The farm types concerned were T41, T42 and T43 describing situation where dairy production as well as cattle meat production were intensively conducted. Once again, the fact that fodder is the core of the livestock production system suggested a climate favourable to biomass production. Despite an important competition between the bovine activities and SHGOAT activities, the pasture areas were larger enough to propose a mixed keeping strategy. In parallel, the stocking density observed being small (<1), outdoor keeping is also conceivable. With 557€.LU-1.year-1, the level of intensification was intermediate but it represents approximately 75% of the production costs; this suggested that only feedstuffs acquisition is expensive; heating or cooling were negligible; this confirming the assumption

made concerning the climate. The regions belonging to the cluster are located In Austria, in Spain, France, Italy, Ireland and the UK. More remarkable was that the regions corresponded to mountainous zones in these countries: Tirol, Auvergne, Limousin, Asturias, Pais Vascos, Valle d'Aosta and Trentino Alto-Adige or Northern Ireland regions were identified as cluster 6. The Azores (Portugal) and the Smaaland med Oearn (Sweden) region were also identified as cluster 6. It appeared that for cluster 6, the intensive SHGOAT activity was limited to mountainous zones where bovine was the only livestock production in use. Consequently this cluster has been called "complement to bovine mountainous SHGOAT".

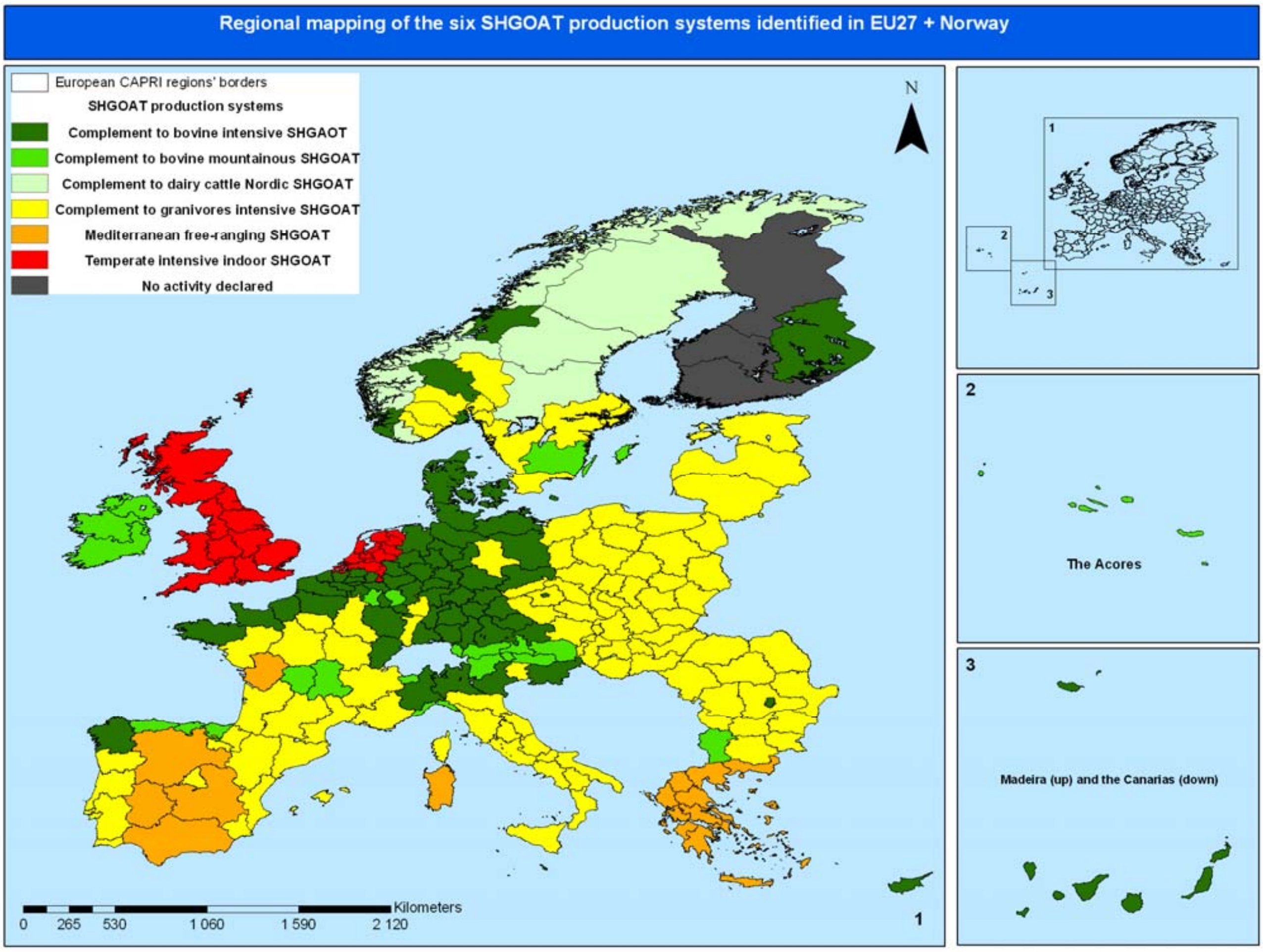

Figure 16: Diversity of the SHGOAT Production Systems in EU27 + Norway

7.1.4. The PORCIN sector

The clustering of the PORCIN activity was processed from a final set of 7 descriptors representing the productivity of the PORCIN activity (total digestible lysine requirement per year, $kg.herd^{-1}.year^{-1}$), the herd size as the percentage of the PORCIN livestock units in the total number of livestock units in a region, the level of intensification of the activity as the cost of the feedstuffs and veterinary products used per year per animal ($€.LU^{-1}$) and as the percentage of the total cost invested to produce one PORCIN livestock unit; the capacity of a region to fulfil its PORCIN herd requirements for energy and protein was approximated from the regional autosufficiency (%) for digestible lysine from "rich protein crops" cultivated in the region (see § - 4.2.3.). Respecting the approach used for grazing animals, a stocking density for monogastric animals has been calculated by dividing the total area (ha) of crops almost directly usable for monogastric livestock feeding (soybean, rape, sunflower, wheat, barley and potatoes) by the number of PORCIN livestock units; it is expressed in LU.ha^{-1}. Finally to assess the turn over and/or to confirm the intensity of the PORCIN production, we considered the yield as the averaged carcass weight of pigs for fattening when delivered to the slaughter plant (kg.head^{-1}).

These descriptors were selected from the initial set of variables describing the PORCIN activity by processing PCA and by a stepwise elimination of the correlations. The results of the PCA on the four rotated component are given in table 7.

Table 7: Results of the PCA – Varimax rotation onto the seven descriptors retained for the PORCIN production description and clustering

	PCA comp.1	PCA comp.2	PCA comp.3	PCA comp.4
Eigenvalue	2,27	1,752	1,001	0,816
Percent	32,424	25,034	14,299	11,658
Cum Percent	32,424	57,458	71,758	83,415
Eigenvectors after rotation				
Intensification (€/LU)	0,725	-0,269	0,478	-0,031
Intensification (%)	0,906	0,152	0,033	0,083
Lysine auto-sufficiency (%)	0,021	-0,074	-0,077	0,992
Total lysine requirement (kg/year)	0,068	0,825	0,188	-0,012
Carcass yield (kg/head)	0,848	0,166	-0,196	-0,04
Stocking density (LU/ha rich. prot.)	-0,048	0,349	0,857	-0,092
Herd size (% herd total)	0,09	0,876	0,08	-0,084

The results of PCA describes clearly that the final weight of individual was correlated to the level of intensification of the production stating that producers willing to rapidly reach the slaughter criteria tended to use largely feedstuffs from market and veterinary products. Together with the individual yield (kg.head^{-1}), these two descriptors were jointly used to characterise the level of intensity of the production (3 modalities from very intensive to natural growth). PCA component 2 linked the total lysine requirement of the herd a year to the herd size; they have been used together to statute onto the importance of the PORCIN production in a cluster (from subsidiary to of primary importance). PCA components 3 and 4 balanced the feeding requirements to the capacity of the region to produce necessary feedstuffs to cover these requirements. All together they were used to describe the potential dependence to the market for feedstuffs provision (3 modalities from very dependent to independent).

Before to interpret the qualitative description of the clusters, the results of the clustering process onto the seven descriptors are given in annex 11; it shows the results of the ANOVA applied on these descriptors by cluster.

Because the PORCIN production is not an activity closely related to one specific land cover, the use of the share in area of certain crops was not considered as previously done with grassland when considering grazing activities. Only three aspects were considered to perform the qualitative description of the PORCIN clusters: the importance, the intensity and the dependence of the PORCIN activity. Table 8 summarizes the qualitative description of the PORCIN production per cluster. However, dimensions such as dominant cropping systems in use, animals assemblages and farm types per cluster were considered separately to provide complementary information for the qualitative description of each cluster.

Table 8: Qualitative description of the seven PORCIN clusters identified

Clusters	Importance	Intensity	Dependence
1	Subsidiary	Normal growth	Independent-dependent
2	Primary	Intensive	Very dependent
3	Subsidiary	Intensive	Dependent
4	Secondary	Intensive	Independent-dependent
5	Secondary	Very intensive	Very dependent
6	Subsidiary	Intensive	Independent
7	Primary	Intensive	Dependent

- Cluster 1 presented the largest proportion of poultry activities (55%) completed by bovine activities (45%); PORCIN activity was present from the "mixed without SHGOAT" animals assemblages (5%). The animals assemblages' profile signified that the PORCIN production for the regions concerned was a subsidiary production. This was verified from the farm types T50 (granivores), T71 (mixed grazing) and T72 (mixed granivores) which were the three major types clustered. In parallel the cropping systems in place were at 60% composed of annuals crops such as cereals, rich protein crops and fodder maize. The rest was composed of fodder grass/maize at diverse ratio. Investments for the PORCIN activity was the lowest for cluster 1: the cost for feedstuffs and veterinary products represented less than 60% of the total production costs. In parallel, after slaughtering, the carcass weight had very common value in EU closed to 85 kg/head. From this, we supposed that the PORCIN producers in these regions could have recourse at a large extent to homemade feedstuffs from cereals and rich protein crops cultivated; and that the daily weight increase was relatively low, asking for a greater fattening duration. Consequently, PORCIN production of cluster 1 was considered as more close to natural growth situation. This could be consequence of higher animal welfare national requirements or of traditional practices inherited from the past. The regions concerned almost all the regions belonging to six countries: Bulgaria, Latvia, Lithuania, Slovenia, Romania (not the Bucuresti region) and Sweden. Cluster 1 has been called "Subsidiary traditional PORCIN".
- In cluster 2, more than 60% of the animals assemblages' profiles was composed of "granivores" and "granivores/ovine" assemblages. The rest was composed of "mixed without SHGOAT" which also integrates granivores production. The complete absence of "poultry" activities suggested that almost all the "granivores" assemblage should correspond to a PORCIN production rather than to a poultry production. Consequently, cluster 2 appeared as very specialized in PORCIN production. This has been confirmed when analysing the farm types' composition: T50 "granivores" was the major type present in the regions followed at less extent by T41 "dairy cattle", T42 "cattle rearing fattening" and T72 "mixed granivores". And later by the highest herd size observed for PORCIN clusters. From the previous results, PORCIN production has been declared as of primary importance for these regions; it is a primary source of revenue for farmers whose are rearing in parallel diverse bovine livestock. It was interesting to underline that the second cluster presented a total livestock revenue representing around 65% of the total agriculture revenue. Moreover, we observed a high level of intensification (694€/LU; 70%) and a very high stocking density per hectare of rich protein + potatoes area: it signified a very intensive production. Together with the standard carcass weight observed it also suggested a fattening period as reduced as possible for a higher turnover and productivity. Finally, corresponding cropping systems were only fodders-based, from "fodder grass>maize" to "fodder maize" (80%). The rest being equally composed of permanent crops and annual maize. Consequently, the regions did not grow rich protein crops, cereals or pulses as sources of feedstuffs for PORCIN production: the level of dependence to

the market was considered as very high for feedstuffs provision. The regions concerned were the Catalonia and Murcia regions in Spain, the Antwerpen and Limburg regions in Belgium, the German Muenster region and five regions in the Netherlands: the Overijssel, Gelderland, Utrecht, Noord-Brabant regions and the Limburg region. The name given to this cluster was "Primary intensive with bovine PORCIN".

- Cluster 3 corresponded to subsidiary PORCIN activity because of a very low herd size (% of the total regional herd), digestible lysine requirement (correlated with the number of livestock units) and stocking density. At the opposite, the investments for the provision of feedstuffs and veterinary products are standard (675€/head; 70%) meaning that despite a subsidiary production, the expectation of an optimal gross margin from the PORCIN activity is the same than for other activities present in region. For that, the regions concerned had at their disposal the largest lysine auto-sufficiency: cropping system was effectively at 85% composed of annual crops (cereals-maize, rich protein crops) and could fulfil approximately 400% of the PORCIN lysine requirements. However, T81 "crops + grazing" being the significant farm type followed by the T42, T43 and T44 types addressing bovine productions (confirmed by the animals assemblages' profile, 85% grazing livestock), farming targeted intensive crops production first and intensive indoor bovine production before all (plant production was 78% of the total agriculture revenue); yielded seeds were certainly destined to the market rather than to be autoconsumed on farm. In these regions, each production (crops as well as bovine, porcine or even ovine) seemed to be very intensive with a generalized indoor keeping strategy. Cluster 2 has been called "Subsidiary intensive with crops PORCIN". The regions concerned were regions in north of France (Picardie, Champagne Ardennes, Lorraine, Haute-Normandie and Ile de France) and in the eastern UK (South-East and North-East regions).

- With a relative herd size around 27% and a medium lysine requirement, the PORCIN activity is of secondary importance for the 114 regions belonging to cluster 4. The profile of animals assemblages was composed at 27% of "bovine", 25% of "mixed without SHGOAT" and of 22% of "granivores". The farm types mostly represented corresponded to the cattle production activities (T41, T42, T43 contributed at 35%). The rest was relatively well distributed between (T50 and T 72) "granivores …" and (T81 and T82) "crops + …" types. The profile appeared relatively diversified and balanced between types and assemblages; this was certainly due to the large set of regions classed as cluster 4. Furthermore, it confirmed that the PORCIN activity was not dominant as every other livestock activities and was of secondary importance. Approximately 50% of the land cover was composed of annual crops and 25% of all fodder grass/maize at variable ratio identified in paragraph § - 6.2.3. The level of intensification is important but closed to the main investment observed when fattening pigs in EU (general averages: 666€/head and 72% of the total cost). On the second hand, the carcass yield was conformed to the common fattening practices in EU. Finally, the regional level of autosufficiency corresponded also to the common situation where feeding strategy is based on the provision of feedstuffs from the market and the PORCIN gross margin is coming from an intensive and rapid turnover of the production cycles (livestock revenue counted for 50% of the total agriculture revenue – crops production activities were important at the same extent than the livestock activities). This PORCIN production system concerned almost all the regions in Austria, Belgium, Germany, France, Poland and Portugal. It also concerned Malta, Cyprus and the Luxembourg. It has been called "Common secondary intensive PORCIN".

- The herd size and the total lysine requirement illustrated a PORCIN production of secondary importance. From the previous cluster, the PORCIN production system was differentiated by the highest yield (115 kg/head) and the highest level of intensification (866€/LU and 80% of the total production cost) describing a very intensive production. The cropping system was composed of 40% of fodder maize and at a less extent fodder grass, 20% of permanent crops and 30% of annual crops when the animals assemblages profile was composed of 55% of granivores + poultry assemblages and of a mix of ovine + bovine (45%). The lysine autosufficiency being very limited, we assumed that the level of dependence to the market for feedstuffs provision was very high. T50 "granivores" and T72 "mixed granivores" were the major farm types identified in the cluster 5 together with T82 "crops + livestock". Consequently, these regions were very specialized in granivores production in parallel of bovine and ovine production; all the livestock productions were considered as important and are performed at a very intensive level. For these reasons, the cluster 5 has been denominated "<u>Primary very intensive PORCIN</u>". The corresponding regions (n=29) are located in Italy (20), in Hungary (7) and in Belgium (the Oost-Vlaanderen and Weat-Vlaanderen regions).

- With very limited herd size and lysine requirement, PORCIN activity was not considered as important for cluster 6. In addition, restricted carcass yield suggested (i) a low-to-medium level of intensification or (ii) a slow rhythm of growth of the animals at constant duration, or (iii) a reduced period of fattening to comply with certain transformation requirements. From available information, we were not able to confirm one of these assumptions. We just considered that the production was less intensive or even extensive. This could be the case for climatic or feeding constrained situations. A look on the list of regions showed that Greece, Portugal, Norway, Slovakia or again Ireland and the UK are concerned. If the first have to play with extreme climatic conditions, the last two countries are located in a temperate and more favourable zone; for them, more extensive practices or specific transformation requirements could explain the production system chosen. For cluster 6, the level of intensification corresponded to standard values (709€/LU) which represented a lower proportion of the total production cost (60%). Other expenditures such as cooling/heating could be necessary in response of the extreme climatic situations. The animals assemblages' profile depicted a livestock production essentially turned toward the ovine activities; "ovine …" assemblages represented around 50% of the total assemblages; the rest corresponded to bovine/ovine and "poultry" production (18%). Regions were specialized in ovine production first, then in bovine and poultry productions, PORCIN being subsidiary. This was verified by a large share of farm type "SHGOAT + other grazing" (37%). With more than 70% of the cropping system dedicated to fodders production and les than 10% to the annual crops productions, the regions were very deficient for lysine supplying. This low lysine autosufficiency could partly explained the subsidiary status of the PORCIN activity; at least, it confirmed the grazing specialisation of the regions. This cluster was called "<u>Subsidiary complement to grazing PORCIN</u>".

- The last cluster grouped together only three regions that a reduced number of cluster (up to 3) didn't succeed to merge with another cluster. These regions were very specific because of the highest lysine requirement and herd size (52%) and the second smallest lysine autosufficiency (3%). The proportion of the livestock revenue in the total agriculture revenue is closed to 75% meaning that these three regions had a livestock-driven economy for which the PORCIN production is of primary importance. The animals assemblages' profile was very simple and composed of the sole "granivores" class. The cops systems was composed of "fodder maize", "fodder grass = maize" and "cereals + other fodders". The two major farm types were T41 "dairy cattle" and"T50 "granivores". In these regions agriculture is made of two main livestock activities: dairy cattle and pigs for fattening production by using fodder grass and maize silage as basic constituents of the ration. Very intensive and very dependent regarding the PORCIN activity, this cluster was denominated "Specialized PORCIN". It concerned the Bretagne (France), the Weser-Ems (Germany) and Denmark regions.

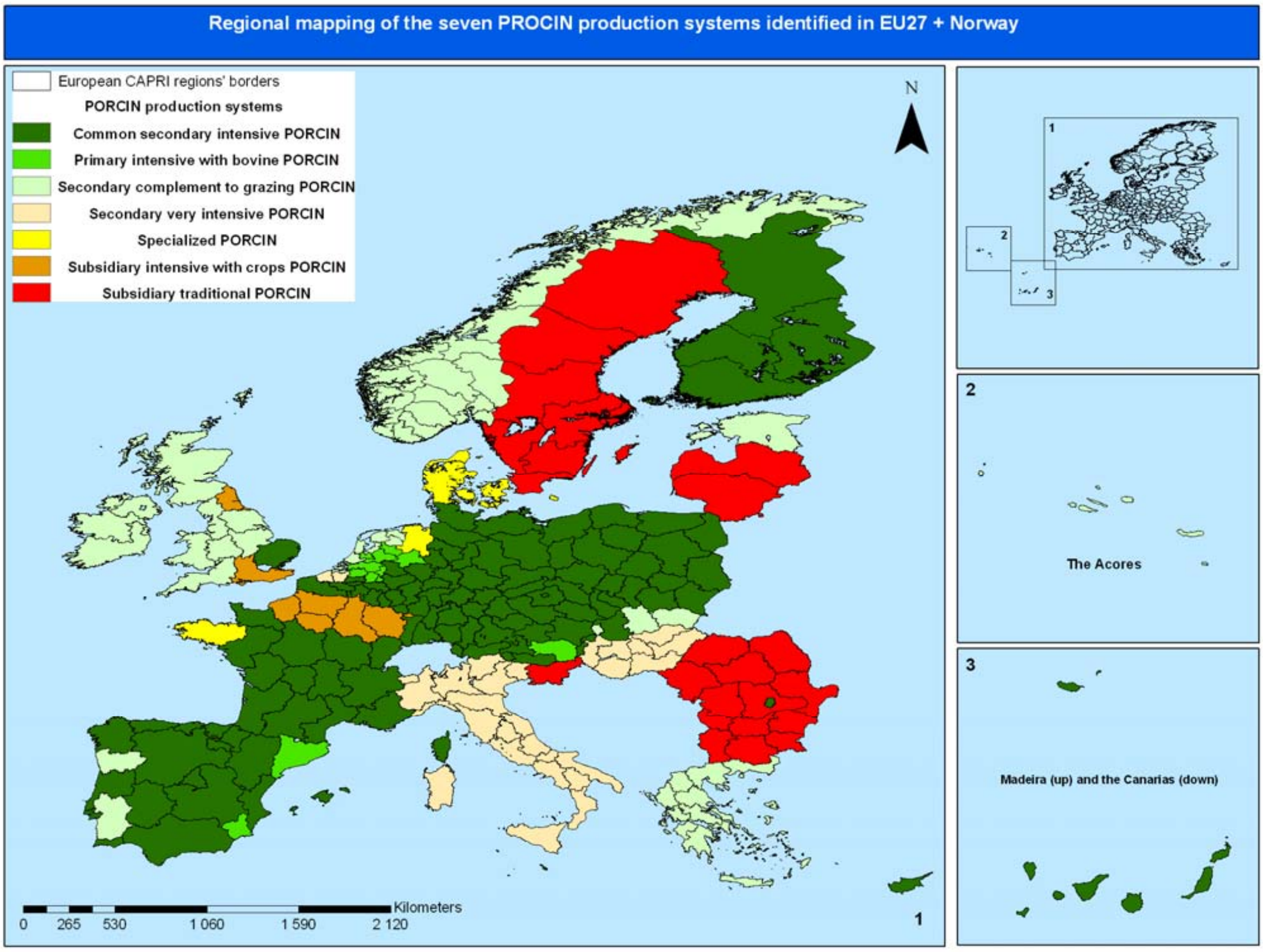

Figure 17: Diversity of the PORCIN Production Systems in EU27 + Norway

7.1.5. The LAHENS sector

For LAHENS, PCA was performed from seven remaining descriptors after elimination of high correlations between initial descriptors. The quantitative descriptor corresponding to the importance of the LAHENS production was the revenue expressed in million of euro; together with the herd size as the percentage of the total number of livestock units in a region corresponding to LAHENS production, it described the importance of the LAHENS production (3 modalities, from subsidiary to of primary importance). The other descriptors were the level of intensification (€/LU) of the LAHENS production which participates to the intensity of the production (3 modalities from normal rhythm to very intensive) together with yield (kg of eggs.year^{-1}.laying hens^{-1}). The feeding strategy (3 modalities from independent to very dependent) describing the level of LAHENS dependence to the market for feedstuffs provision was determined from three descriptors: the level of intensification expressed in % of the total cost – the stocking density calculated for granivores as the number of livestock units per hectare of rich protein crops (soybean, sunflower and rape for oilseeds, wheat and grain maize for cereals, and pulses areas) – and the regional level of autosufficiency for digestible lysine as the percentage of the monogastric lysine requirement covered by the rich protein crops cultivated in the region. Finally, the level of constraint due to a particular (agro)climatic situation was discussed by considering the level of intensification expressed in % from which a picture of the other production costs such as heating/cooling can be determined (3 modalities: low to high).

Results of the PCA are shown in table 9.

Table 9: Results of the PCA – Varimax rotation onto the seven descriptors retained for the LAHENS production description and clustering

	PCA comp. 1	PCA comp. 2	PCA comp. 3	PCA comp. 4
Eigenvalues	1.871	1.254	1.189	0.971
Percent	26.731	17.913	16.992	13.88
Cum Percent	26.731	44.643	61.635	75.51
Eigenvectors after rotation				
Intensification (€/LU)	0.771	0.459	0.124	0.003
Intensification (%)	-0.033	0.918	-0.073	-0.057
Revenue (€)	0.038	-0.097	-0.034	0.92
Lysine autosufficiency (%)	0.09	0.288	-0.659	0.076
Yield (kg/head)	0.91	-0.188	-0.056	-0.023
Stocking density (LU/ha)	0.059	0.155	0.796	0.128
LAHENS share (%)	-0.51	0.138	0.303	0.556

From the results of the ANOVA processed on the seven remaining descriptors (annex 12), a qualitative description of every one of the clusters was performed. The results are presenting in table 10.

Table 10: Qualitative description of the seven LAHENS clusters identified

Clusters	Importance	Dependence	Intensity	(Agro)climatic situation
1	Primary	Dependent	Natural rhythm	Medium
2	Subsidiary	Dependent	Intensive	Low
3	Primary	Very dependent	Intensive	Low
4	Subsidiary	Dependent	Very intensive	High
5	Subsidiary	Dependent	Intensive	Low

- Cluster 1 was presenting a high proportion (>55%) of the UAA used for annual crops (cereals, rich protein and grain maize) and around 15% for permanent crops and the proportion of fodder crops was consequently very low. Such a cropping system was not relevant for grazing breeding and it was not surprisingly that 50% of the animals assemblages was composed of poultry, granivores/ovine and granivores assemblages. The second highest assemblage was "Mixed without SHGOAT" (15%) which could also contain a certain proportion of poultry activities. The livestock activities of the cluster 1 seemed to be centred on the production of granivores (pigs for fattening) and poultries rather than on the production of grazing animals. This was confirmed by the preponderance of the T50 "granivores" and T72 "mixed granivores" farm types and then of T71 "mixed grazing" and T82 "crops + livestock". As a consequence, together with the porcine activities, production of poultry was perceived as of primary importance; ovine and then bovine activities were secondary productions. On the other hand, the LAHENS revenue was medium level when the herd size was high: if LAHENS were numerous, they didn't contribute so highly to the revenue. This suggested that LAHENS production for this cluster was not intensive. It has been verified when considering the intensity of the production: the yield was the lowest observed (9.63 kg/head, 50% of the maximum observed for cluster 4) and the investments consented for feedstuffs and veterinary products provision was the lowest (445€/LU). The level of intensification expressed in % showed that the regions belonging to this cluster were exposed to a low-to-medium level of agro-climatic constraint; almost 90% of the investments are destined for feedstuffs and veterinary products acquisition – a standard proportion in Europe. All together these elements suggested a non intensive production respecting a certain normality of the rhythm of production because of more animal-friendly practices or because of a reduced capacity of investment. The low level of intensification (E/LU) not being counterbalanced by a medium/high lysine autosufficiency, the second hypothesis could be real. The LAHENS production system of cluster 1 has been called “Primary economically restricted LAHENS”. The regions concerned corresponded to almost all the regions of Greece, Poland, Romania, Bulgaria and the Latvia, Lithuania, Cyprus and Slovenia.

- For the second cluster, the cropping system was well balanced between annual crops (44%) and fodder crops (45%) – the remaining 10% being covered by permanent crops. In parallel, only 25% of the animals assemblages was composed of “poultry” and “granivores” – the rest corresponding essentially to “bovine” and “Mixed without SHGOAT”. The total revenue was low and the herd size (%) very low. The LAHENS production for cluster 2 appeared as a subsidiary activity to the bovine activity. Because of important investments and a limited lysine autosufficiency, the cluster 2 was considered as dependent to the market for feedstuffs and veterinary products supply. The prevalent use of marketed feedstuffs was related to the level of intensity; with a mean yield higher than the European average (14.73 ± 3.25 kg/head/year), LAHENS production for cluster 2 appeared as intensive. Finally, the proportion of the production costs not invested for animals feeding and health was reduced (less than 10%); the regions concerned were not located in constrained agroclimatic zones. The production system of cluster 2 was relatively standard and respected a large range of practices and decisions traditionally set up in Europe; it has been consequently denominated “Subsidiary common intensive LAHENS”. The number of regions being huge, readers should refer to the figure 18 to visualise the regions concerned.
- Cluster 3 differed from the two first clusters first, because of the high importance of the LAHENS activity (highest revenue and herd size observed) and because of a very limited lysine autosufficiency (13.13%) asking for the purchasing of a very large part of the feedstuffs and veterinary products necessary for intensive production (yield = 14.69 kg/head/year). Intensive and very dependent, the LAHENS production of cluster 3 was of primary importance. The LAHENS production (25%) was generally accompanied by “granivores” (28%), “Mixed without SHGOAT” (25%) and “ovine …” (10%) assemblages. In parallel of the prevalence of monogastric livestock, the cropping system was composed of one third of annual crops and 2 thirds of fodder crops. This described a situation where livestock production was relatively diversified with monogastric productions dominance. No significant farm types were observed; almost all the farm types were represented (>50th percentile) with at some extent the prevalence of “dairy cattle” (T41) and “SHGOAT + other grazing” (T44). The level of intensification (%) being high, no particular agro-climatic constraint was retained – it could correspond to favourable temperate situations. All together, the data seemed to describe regions where granivores and grazing productions were of primary importance. At the opposite of the grazing activities which had dedicated fodder areas at its disposal, the LAHENS feeding is based on ration made of feedstuffs from the market. For these reasons, cluster 3 was called

"Primary very dependent LAHENS". Half of the regions in the Netherlands, in the UK, in Slovakia, Hungary, Norway, Italy and Spain were concerned.

- With the highest yield and one of the lowest lysine autosufficiency, this cluster could be dependent on the market to fulfil LAHENS requirements. When considering the cropping system, the regions presented a simple share of the total UAA with 87.5% of "annual cereals + …" and 12.5% of "fodder grass = maize"; the proportion of rich protein crops being null, the supplying of protein to LAHENS activities was very limited. And the LAHENS activity was effectively dependent on the market. In this cluster, 62.5% of the animals assemblages corresponded to bovine (50%) and "grazing"; the rest was composed by the sole "Mixed without SHGOAT" (37.5%). The profile of animals assemblages suggested a grazing dominant profile which didn't dispose of large fodder areas to be fed. Thus, indoor rearing with marketed feedstuffs seemed usual practices for all species. A look on the intensification (%) showed that more than 40% of the total production cost was used for something else than feeding. This could correspond to regions with important agroclimatic constraints. Finally, the assemblages' profile, the revenue and the herd size showed that LAHENS was a subsidiary production in these regions. To summarized all these characteristics, the cluster 4 was denominated "Subsidiary climatically constrained LAHENS". It corresponded to the Swedish regions.
- The last cluster presented the highest level of intensification (€/LU and %) despite a very high lysine autosufficiency (320%); it has been considered as dependent on the market for feedstuffs supply. The revenue as well as the herd size depicted an activity of subsidiary importance. And the intensification (%) indicated that no particular constraint should be applied on the LAHENS activity in these regions. And until now, cluster 5 appeared as very similar to cluster 2.However, when analysing the cropping system and animals assemblages' profile, we observed a very specialized farming system: 75% of annual crops (rest was fodders) and almost 85% of "bovine + …" activities (17% of "poultry"). Consequently, in these regions the LAHENS activity was perceived as a complement to the bovine activity. But in the same time, these regions presented the lowest livestock revenue (35%) meaning that the economy of these regions was based on the plant production rather than on the livestock production. If bovine production (T4 and T43 were >75th percentile) could be considered as of primary importance, LAHENS was a niche market for certain holdings or a diversification tool to counterbalance risk of failure of the bovine activity. This cluster was called "Complement to crops LAHENS". These twelve regions were situated in France (11) and in the Check Republic (the Praha region).

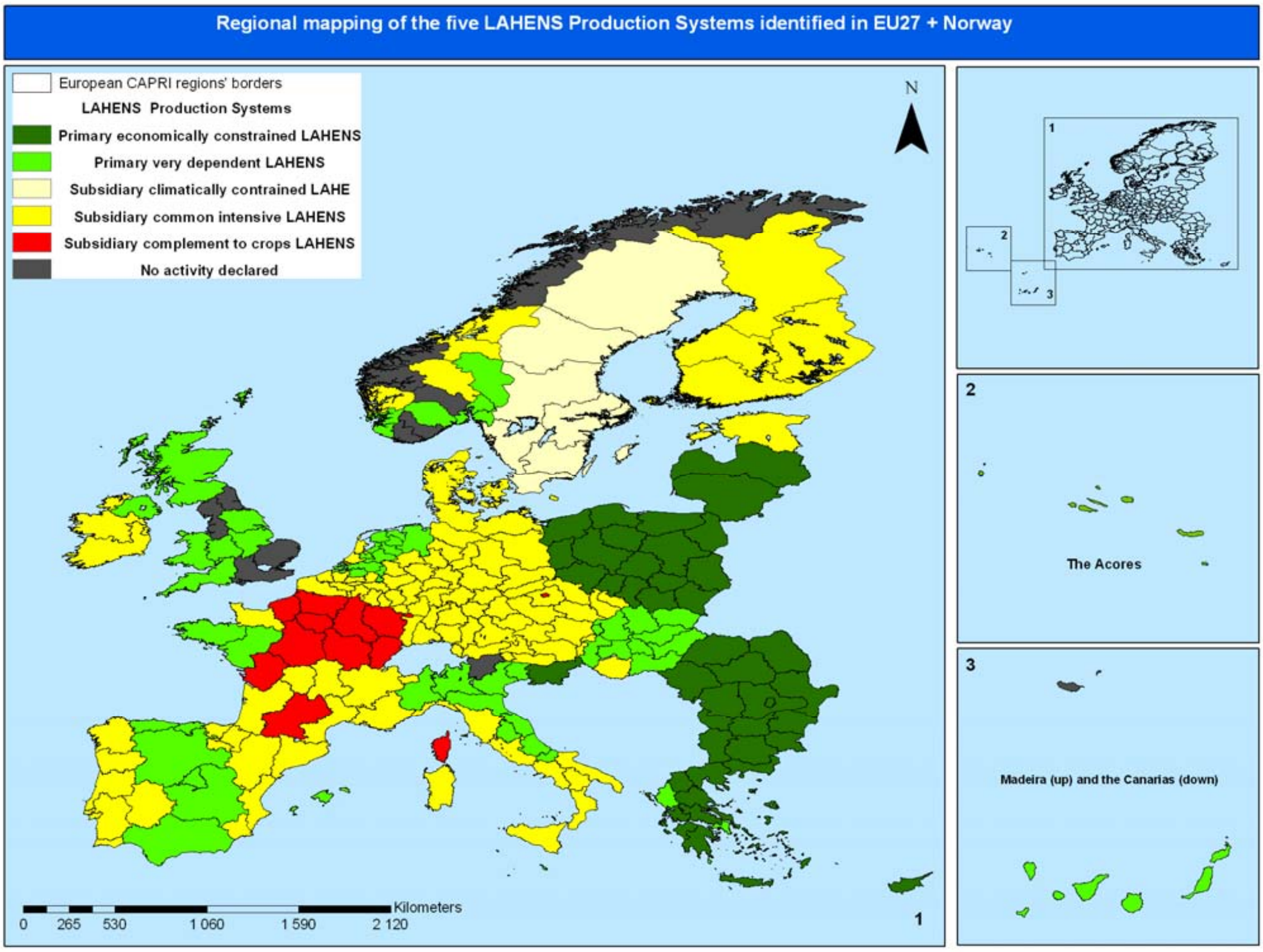

Figure 18: Diversity of the LAHENS Production Systems in EU27 + Norway

7.1.6. The POUFAT sector

From the beginning, we assumed that POUFAT production systems should follow the same trends tan the ones observed for LAHENS; consequently, we used the same seven descriptors to process the multivariate analysis of the regional variability. Results of the PCA are shown in table 11.

Table 11: Results of the PCA – Varimax rotation onto the seven descriptors retained for the POUFAT production description and clustering

	PCA comp. 1	PCA comp. 2	PCA comp. 3	PCA comp. 4	PCA comp. 5
Eigenvalue	1.8	1.29	1.08	0.87	0.81
Percent	25.66	18.46	15.46	12.44	11.53
Cum Percent	25.66	44.12	59.59	72.03	83.56
Eigenvestors after rotation					
Intensification (€/LU)	0.00	0.93	-0.05	-0.01	0.02
Intensification (%)	0.14	0.55	0.35	0.29	0.2
Revenues (M€)	0.84	0.11	-0.18	0.23	-0.14
Lysine autosufficiency (%)	-0.02	0.05	0.94	0.08	-0.1
Yield (kg/head)	0.04	0.08	0.09	0.95	0.03
Stocking density (LU/ha)	0.07	0.1	-0.09	0.04	0.96
Herd size (%)	0.82	-0.03	0.19	-0.15	0.28

Then, we performed a qualitative description of the seven clusters identified from the results of the analyse of variance applied to the seven remaining descriptors. Results of the ANOVA are presenting inside annex 13. From this, four following dimensions of the production systems have been characterized (Table 12):

- The importance of the POUFAT production (3 modalities, from subsidiary to of primary importance) by considering the POUFAT revenue (€) and relative herd size (%),
- The level of intensity of the production (3 modalities, from normal rhythm to very intensive) when considering together the level of intensification (€/LU) and the yield (kg/head),
- The level of dependence on the market for feedstuffs and veterinary products supplying (3 modalities, from independent to very dependent) when considering the level of intensification (%), the lysine autosufficiency (%) and the stocking density (LU/ha of rich protein, wheat, grain maize and pulses),
- Finally, the level of agroclimatic constraint (3 modalities from low to high) buy taking into account the complement of level of intensification (%) as an indication of the production cost dedicated to production practices other than the feeding (heating, cooling…).

Table 12: Qualitative description of the seven POUFAT clusters identified

Clusters	Importance	Dependence	Intensity	(Agro)climatic situation
1	Subsidiary	Independent	Natural rhythm	High
2	Subsidiary	Dependent	Intensive	Low
3	Secondary	Very dependent	Intensive	Low
4	Subsidiary	Dependent	Very intensive	Low
5	Primary	Very dependent	Very intensive	Medium
6	Subsidiary	Dependent	Intensive	Medium
7	Subsidiary	Very dependent	Very intensive	Medium

- The revenue as well as the relative herd size of cluster 1 indicated POUFAT as a subsidiary production in complement to the bovine and ovine activities. The POUFAT number of livestock was explained by the monogastric assemblages (25% of the complete profile) observed from which the "poultry" activity counted for 11% and the PORCIN and LAHENS activities for 14% of the complete profile. The profile of the animals assemblages showed a very diversified livestock production where all the activities were present; at the exception of T44 (SHGOAT), all the farm types showed values higher or equal to the 50th percentile values. Dependence on the market for feedstuffs provision was considered as medium; the lowest investment for feeding and health (1255€/LU), a stocking density almost null and a lysine autosufficiency relatively high suggested the possibility to have directly recourse to regional crop production to feed POUFAT; cluster 1 was considered as independent. This was explained when considering the cropping system: around 60% of the total UAA corresponded to annual crops and 10% were permanent crops. The yield as the carcass weight of POUFAT when slaughtered was of standard value. Together with level of intensification (€/LU), it suggested a non intensive production practices where individual growth duration could be higher and closed to a more natural rhythm of growth. Finally, the complement to the level of intensification (%) being the highest observed, we assumed other production costs to be considered for POUFAT production: this could be the consequence of important agroclimatic constraints. The corresponding regions were located in Austria, Bulgaria, Cyprus, Germany, Italy, Lithuania, Poland and Sweden and corresponded to continental temperate or cold climates where heating and cooling costs could be important. Cluster 1 has been called "Subsidiary constrained natural rhythm POUFAT".

- Cluster 2 corresponded to a production system of subsidiary importance and was very similar to the previous one. Major differences were a higher level of intensification (€/LU) and a higher yield suggesting a more intensive production system. The cropping system was centred on the fodder activities (55%) and cattle rearing and fattening activity (T42 and T43, >75th) was the major type of livestock production met. The POUFAT activity was represented essentially through the "ovine/poultry" assemblage; the ovine production was certainly a secondary production after the cattle rearing activity; it had at its disposal a high proportion of permanent crops(24%) for free-ranging feeding strategy. As cattle rearing activity was fed from fodders and especially from fodder maize (an intensive practice), we assumed that the same trend should be applied to the POUFAT activity. We have considered the POUFAT activity as intensive; it was confirmed by the high yield observed. A medium stocking density, a lower lysine autosufficiency together with a high intensification level described a dependent situation where producers should have recourse to the market to fulfil the POUFAT feeding requirements. Finally the complement of the level of intensification (%) was closed to 83% and suggested no particular other production constraint. The cluster was called "Subsidiary with cattle intensive POUFAT". Regions were located in Belgium, Spain Greece and France; other regions such as Malta, Slovenia or again the Luxembourg were concerned too.
- Cluster 3 contained only one region. For this reason, it has been very difficult to conclude of the real production system in place. Only subjective interpretation was possible in absence of intra-cluster variability. Whatever the number of clusters (>3) tested, this region was always identified alone. It was a very particular region composed of 100% of the permanent crops assemblage (in fact 45% of fodders was also declared) with one single assemblage: "ovine/poultry". Consequently, POUFAT appeared as a production system of secondary importance completing the ovine activity in the region. This region was the Canarias region in Spain (ES70). With one prevalent farm type (T44) counting for 45% of the farms, and a livestock revenue of 9.6% of the total revenue, all the livestock production could be considered as a "subsistence production" or destined to the local market without high market standards. On the other hand, the absence of rich protein crops, a relatively standard yield and the highest stocking density suggested a high dependence on the market to feed POUFAT animals. The name given to this production system was "Secondary very dependent Canarias POUFAT".
- Cluster 4 had the second highest intensification level (€/LU) and in the same time the highest autosufficiency level for lysine. Yield being the highest, it required important quantities of feedstuffs per animal to fulfil energy and protein requirements. A look on the crops groups share showed that fodders and cereals were equally cultivated (35% of the total UAA); but oilseeds areas represented 7.5% of the total UAA, the highest share observed between clusters for this crop group. Consequently, the energy and protein availability appeared as not limiting if POUFAT would be the sole livestock production. However, the profile of the animals assemblages showed that 80% of the animals corresponded to grazing animals and especially of cattle for rearing and fattening (T42 and T43) which require high amount of energy and protein. POUFAT not being of primary importance (it has been considered as subsidiary), we assumed that most of the feed availability was preferentially attributed to the cattle activities. So, POUFAT was considered as dependent and very intensive to reach specific yield observed. On the other hand, intensification (%) closed to 86% suggested that no particular constraints had to be taken into account. Cluster 4 appeared as "Subsidiary with cattle very intensive POUFAT". All the regions (11) were located in France and coincided with the eleven regions called "Complement to crops LAHENS".

- Cluster 5 was the cluster for which POUFAT appeared as of primary importance: highest animals share and highest revenue were observed. The animal assemblages' profile was made of granivores (33%) and of poultry (40%). With a very limited lysine autosufficiency and a standard yield, it appeared normal to observe a medium level of intensification (around 1500 €/LU); POUFAT production has been considered as very dependent. Moreover, major farm types were T50 and T72 meaning that monogastric production was prevalent (followed by cattle rearing and fattening) and that porcine and poultry activities could compete for regional feedstuffs availability. Porcine as well as poultry activities being dominant productions and conducted indoor generally at high production intensity, the observation of a high carcass weight (yield) conducted to consider the POUFAT production system as very intensive. The complement to the total production cost was considered as medium (25%) suggesting supplementary investments to be granted. Unfortunately, neither the list of the regions concerned (in France, Hungary, Italy, the UK and in less extent in Spain) nor the details of the total production cost inside CAPRI dataset allowed us to identify the reasons of the supplement; we assumed that the investments were due to decision of modernization (buildings, manure collecting system…) or diversification (transformation chain, packaging…). This cluster was called "<u>Primary very intensive POUFAT</u>".
- When considering the animals assemblages, livestock activities in cluster 6 appeared as balanced between grazing activity (50%) and monogastric activities (granivores = 20% and poultry = 30%). It has been confirmed by the farm types observed: T50 and T72 were prevalent followed by T41 "dairy cattle". On the other hand, the herd size equalled an intermediate value (5.5%) and the POUFAT revenue was relatively low. Altogether, the last two arguments suggested a subsidiary production when the first suggested a secondary production. It was the first time that we were not able to statute clearly on the importance of a production. The analyse of contingence of the animals assemblages containing more approximation than the ANOVA when the relative herd size is obtained from the real number of livestock units per species in a region, we choose to conform to the last result and POUFAT in cluster 6 was considered as a subsidiary production system.

  Despite a high proportion of annual crops (60%), the level of lysine autosufficiency was very limited. Main area were destined to fodders (for dairy cattle) and cereals when oilseeds (5%) and even more pulses (0.8%) were limited. The POUFAT was considered as dependent on the market to fulfil feeding requirements. Yield of 1.2 kg/head was the lowest observed; extensive practices not existing for poultry, it suggested a decrease of the growth period duration to allow producers to increase the number of production cycles in a year or to match the specific market requirements. Finally, the complementary investments to the total production cost were relatively important (25%) – according to the list of countries concerned (Slovakia, Norway, Romania, Portugal, Latvia, Ireland or again Finland), the climatic constraint could explain this supplementary investments. "<u>Subsidiary constrained intensive POUFAT</u>"
- The last cluster was particular with area dedicated at 100% to fodders activities and a profile of the animals assemblages showing predominant grazing activities (85%) and complementary granivores activity (15%). The main farm types were T41 and T44 describing a strong preference for milk production in the corresponding regions. The herd size as well the revenue confirmed that POUFAT is a subsidiary production in cluster 7. Even if subsidiary, the level of investment was the highest (2400€/LU) observed. The fact that Fodders, root crops and industrial crops were the major groups occupying the total area suggested the null availability of rich protein crops to feed animals and consequently a very high dependence on the market. Together with the level of intensification (€/LU), a standard yield suggested an intensive-to-very intensive production with a high turnover. To decide of the final level of intensity, we

then checked the livestock revenue (50% of the total agriculture revenue) and the total UAA: the regions belonged to the same country, The Netherlands and the total UAA is very limited regarding the total agriculture revenue. Consequently, each agriculture activity must be very intensive to justify land occupation from agriculture activities. We conclude (subjectively) that POUFAT should be very intensive activity. The cluster was called "Subsidiary very dependent POUFAT".

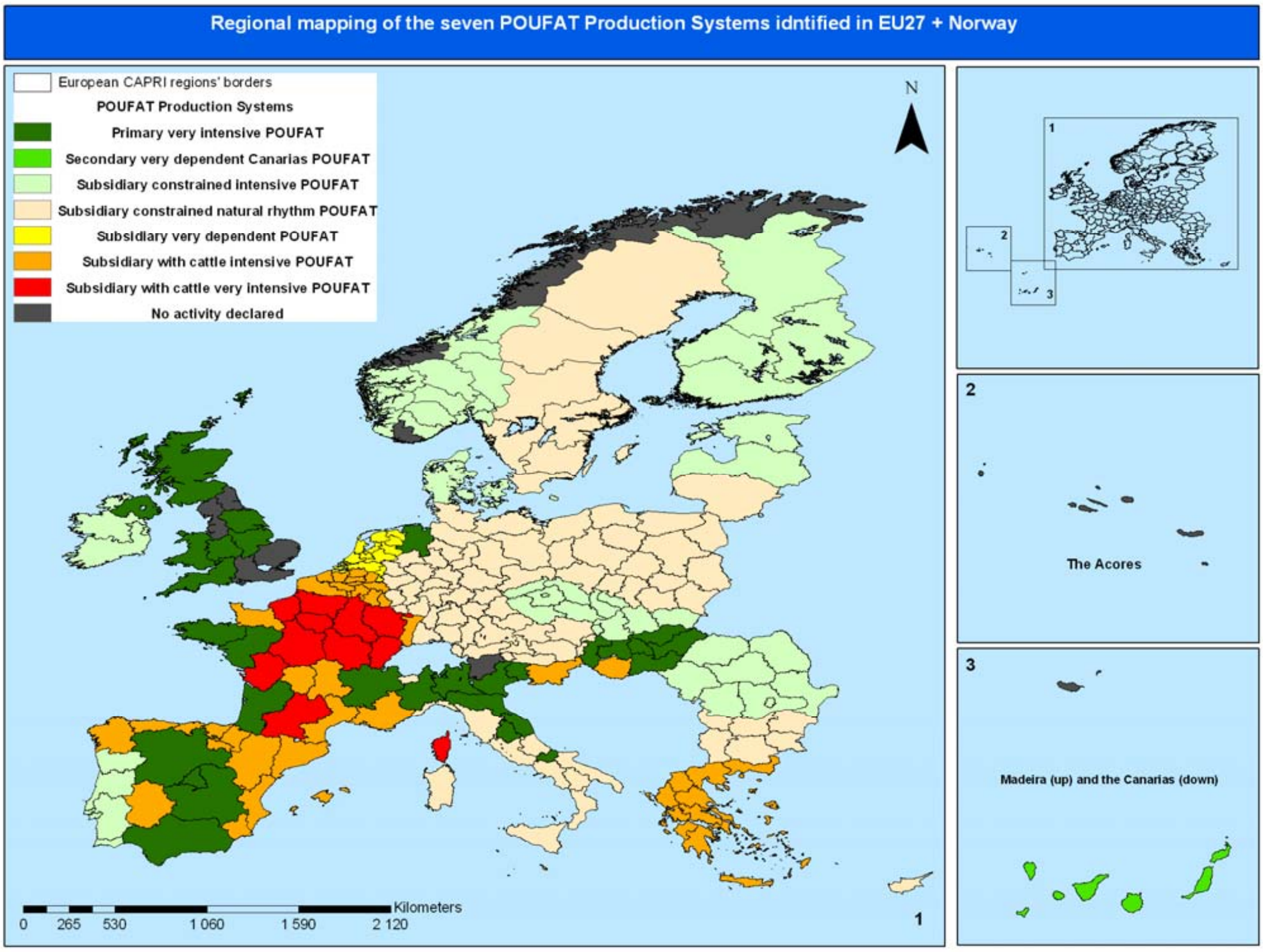

Figure 19: Diversity of the POUFAT Production Systems in EU27 + Norway

8. Ranking and sampling of the regions

Every survey requires the selection of those individuals which should provide the necessary and sufficient information to describe of the effects of the tested factors. This set of individuals is called sample. The sample comes from larger group of individuals (i.e. the targeted population) from which we expect general statements based on the sample findings (Remenyi *et al.*, 2007). The sample must be ideally chosen so that no significant difference exists between the sample and the population in any important characteristics, the model being used as a model for the whole population.

But to be useful to characterize the population, sample must be representative of the whole population otherwise results would be biased and not applicable to the population. To avoid bias and to assure a sufficient level of representativeness, we applied a *probability sampling* technique. Probability sampling uses some random procedure for the selection of the individuals; this is done to remove the possibility of selection bias. Each individual of the whole population has a known probability, not necessary equal, to be sampled. And the probability sample obtained can be rigorously analysed by means of statistical techniques, whereas it's not applicable for *non-probability* techniques.

The type of probability sampling chosen was a *stratified sampling*: the whole population is made of strata (i.e. clusters) from which random samples are drawn from each of the strata. In our case, strata corresponded to "*livestock sector clusters * climatic clusters*" ; for instance, 5 clusters have been identified for POUFAT; together with the 8 climatic clusters identified, this gives 40 possible strata to be randomly sampled.

Sample size i.e. the minimum recommended number of regions to consider when assessing the diversity of the manure management strategies in place in EU27 + Norway, is statistically determined. The results expected from the survey is the average percentage of liquid/mixed/solid manures produced, the percentage of manures stocked using a certain stocking material or again the percentage of manures sprayed on fields with a certain spraying material, this per production system and per livestock sector. Thus, the situation corresponds to *the determination of the sample size needed to estimate a population proportion (as percentage) to a specified margin of error, within a specified level of confidence* (Remenyi *et al.*, 2007). This corresponded to probabilistic determination of sample size when sampling an infinite population where the expected sample will be less than 10% of the population. To that end, it was assumed that manure practices, as a discrete variable, were described statistically by the binomial distribution with only two parameters:

p = the proportion of liquid manures, and
$q = 1 - p$, the proportion of non-liquid manure.

The true proportion of liquid manure being unknown, rule of thumb is to consider p equal to 0.5 (50%). Then, the sample size was determined by considering an acceptable margin of error (d = 0.1 or 10%) in the estimate of p and the probability (α = 0.1) of not achieving this margin of error. This led to use of the normal approximation to the confidence interval given by the formula:

$$\hat{p} \pm t_\alpha s_{\hat{p}} \qquad \text{(equation 15)}$$

where $\hat{p}$ = observed proportion of anomalous reference parcels (0.0576),
t_α = the value of the Student's t-distribution for n-1 degrees of freedom and
$s_{\hat{p}}$ = the standard error of $\hat{p}$.

The desired margin of error is then:

$$d = t_\alpha s_{\hat{p}} = t_\alpha \sqrt{\frac{\hat{p}\hat{q}}{n}}$$ (equation 16)

Solving for n, the sample size required for an infinite population is:

$$n = \frac{t_\alpha^2 \hat{p}\hat{q}}{d^2}$$ (equation 17)

Finally, if the sample size equals more than 10% of the initial population, the procedure is to calculate the sample size from equation 3 above and then to correct it with the following finite population correction:

$$n' \cong \frac{n}{1 + (n / N)}$$ (equation 18)

where *n'* = estimated sample size required for finite population N,
n = estimated sample size required for an infinite population,
N = total size of the finite population (243 regions).

In our case where p= 0.5 (q= 0.5), *p* is estimated within an error limit of ± 0.1 (10%) with α = 0.1 (t_α = 1.645). From equation 17:

$$n = \frac{(1.645)^2 (0.5)(0.5)}{(0.1)^2} = 67.65$$

Because the 67.65 regions to be sampled (n) equalled more than 5% of the total number of regions (N=243), the finite population correction was applied and the final number of region to sample is <u>53.09 regions</u> rounded at 54 as the minimum number of regions necessary to obtain statistically representative sample of the whole population. This number is valid for all the six livestock sectors.

Then, for *one given livestock sector*, we calculated the corresponding proportion for each one of the "*climates * LPS*" sub-strata and we multiplied this proportion to the minimum number of regions to be sampled (53.09) to obtain the number of regions *i* to be sampled from this particular "climate*LPS" association[21]. Regions corresponding to a "climate*LPS" association were then randomly ranked and the first i[th] regions per association were labelled to be sampled during the survey on manures management strategies.

For each livestock sector, we obtained a list of regions presenting:

- the LPS denomination
- the corresponding climate association
- the number of regions by association
- the number of regions to be sampled per association
- the leader regions randomly selected
- and the other regions corresponding to the association but not randomly selected (they could be switched with leader regions to avoid overload of a certain national expert).

[21] For instance: 3 regions were identified as "*Primary very intensive POUFAT * Alpine*" corresponding to a proportion of 0.0123 over the total number of 243 regions, multiplied by 53.09 equalled 0.66 region rounded up at 1 region for this particular association

The different lists obtained are presented in the following tables (from table 13 to table 18) respecting the order in which livestock sectors were considered hereinbefore. Lists of regions per "climate*LPS" association are one possible ranking of the regions; anybody who wants to conduct survey from our results could decide of other regions to be surveyed but the change should be undertaken inside each single association to respect the approach from which classifications were done.

Table 13: List of the leader regions per BOMILK "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
Climate constrained bomilk	Alpine	4	1	AT33	ITD2 SI ES21
Climate constrained bomilk	Arctic	8	2	SE08 FI13	NO122 NO233 SE07 NO111 NO121 FI1A
Climate constrained bomilk	Continental cold	6	2	FI18 NO231	FI19 NO123 SE06 FI20
Climate constrained bomilk	Continental temperate	1	1	SE09	
Climate constrained bomilk	Mediterranean dry	4	1	PT20	ITC3 ES12 ES13
Climate constrained bomilk	Oceanic cold	7	2	NO243 NO252	NO242 AT34 NO241 NO244 AT32
Climate constrained bomilk	Oceanic temperate	2	1	ITC2	BE34
Extensive grass bomilk	Alpine	2	1	UKL	UKM
Extensive grass bomilk	Oceanic temperate	11	3	UKD UKC UKE	UKH UKK IE01 UKF UKN UKJ UKG IE02
Free-ranging subsistence bomilk	Alpine	1	1	ITD4	
Free-ranging subsistence bomilk	Continental temperate	18	4	PL62 EL13 PL32 PL63	BG04 AT11 PL22 BG01 PL51 PL33 BG02 BG05 PL42 PL21 PL52 BG06 PL43 BG03
Free-ranging subsistence bomilk	Mediterranean dry	25	6	ES62 EL41 EL24 EL30 ES30 ES23	ES41 ES61 ITG2 ES24 EL42 EL25 PT17 ES43 ITF4 PT15 EL12 ES42 ITG1 ES51 EL43 EL14 ITF3 ES52 ES53
Free-ranging subsistence bomilk	Mediterranean wet	12	3	EL11 ITE3 ES22	EL22 ITE4 ITE1 ITE2 EL23 ITF1 EL21 ITF2 ITF6
Grazing complement bomilk	Alpine	4	1	SE0A	FR63 AT21 AT22
Grazing complement bomilk	Arctic	1	1	NO232	
Grazing complement bomilk	Continental cold	9	2	LV NO254	EE SE02 NO262 NO255 NO253 NO261 SE01
Grazing complement bomilk	Continental temperate	30	7	SK04 CZ03 RO08 AT12 DE26 SK01 FR82	CZ06 CZ05 RO03 RO04 CZ04 RO02 RO05 CZ08 HU03 HU06 RO07 CZ01 HU04 SE04 SK03 HU02 RO06 CZ02 HU01 SK02 CZ07 HU05 HU07
Grazing complement bomilk	Mediterranean dry	2	1	PT18	FR83
Grazing complement bomilk	Mediterranean wet	6	2	PT16 FR81	FR61 FR62 ITF5 FR53
Grazing complement bomilk	Oceanic cold	1	1	NO251	
Grazing complement bomilk	Oceanic temperate	12	3	FR42 FR26 DE92	DE91 FR24 DE12 DEB3 DE71 FR21 FR10 FR22 DEA4
Intensive grass+maize bomilk	Alpine	8	2	PT11 DE13	DE21 DE14 ES11 FR43 DE27 AT31
Intensive grass+maize bomilk	Continental cold	1	1	LT	
Intensive grass+maize bomilk	Continental temperate	18	4	DE24 DE23 PL11 DE25	DE73 PL31 DE40 PL34 DK PL41 DEE0 RO01 PL12 DED0 PL61 DE80 DEG0 DE22
Intensive grass+maize bomilk	Mediterranean wet	5	2	ITD3 ITD5	FR51 ITC4 ITC1
Intensive grass+maize bomilk	Oceanic temperate	41	9	NL33 DEF0 DE93 DEA1 NL12 DE72 DEB2 DEA2 FR25	FR30 DEC0 DE94 FR52 FR23 FR72 NL34 BE33 LU00 NL13 NL31 DE11 NL11 NL32 FR41 DEA5 NL23 FR71 DEB1 BE32 BE24 BE25 BE23 NL42 NL22 NL21 BE22 BE21 BE31 DEA3 NL41 BE35
Mediterranean intensive bomilk	Mediterranean dry	4	1	ES70	CY MT PT30

Table 14: List of the leader regions per BOMEAT "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
Complement to ovine BOMEAT	Alpine	13	3	ITD2 FR43 AT33	ES21 DE14 ITD4 DE13 SE0A ES11 AT22 AT21 AT31 SI
Complement to ovine BOMEAT	Arctic	3	1	NO232	FI1A NO233
Complement to ovine BOMEAT	Continental cold	10	3	NO255 NO123 SE02	LT NO261 NO262 NO254 SE01 FI18 NO253
Complement to ovine BOMEAT	Continental temperate	14	4	SK03 RO06 RO02 FR82	RO07 RO03 SE04 RO04 RO08 DE73 BG04 RO05 RO01 SK04
Complement to ovine BOMEAT	Mediterranean dry	11	3	ITG1 PT18 PT20	FR83 PT15 ES23 ITG2 ES30 EL42 ITF4 ITF3
Complement to ovine BOMEAT	Mediterranean wet	15	4	ITF6 PT16 ES13 ITE1	ITC3 ITE3 ITE4 ES12 ITF5 ITF2 EL21 ITF1 FR81 ES22 ITE2
Complement to ovine BOMEAT	Oceanic cold	4	1	NO244	AT34 NO251 AT32
Complement to ovine BOMEAT	Oceanic temperate	8	2	DE72 FR71	ITC2 DEB1 DEB2 BE34 DEC0 DEA5
Complement to porcine BOMEAT	Continental temperate	15	4	CZ04 HU03 CZ05 HU02	CZ06 HU04 SK01 HU05 AT11 CZ02 SK02 HU07 HU06 CZ03 CZ07
Complement to porcine BOMEAT	Oceanic temperate	6	2	UKG UKC	UKH UKE UKF UKJ
Intensive grass maize BOMEAT	Alpine	2	1	UKL	FR63
Intensive grass maize BOMEAT	Mediterranean dry	3	1	ES61	ES43 ES41
Intensive grass maize BOMEAT	Mediterranean wet	6	2	ITC1 FR62	ITD3 FR61 ITC4 FR51
Intensive grass maize BOMEAT	Oceanic temperate	12	3	FR23 FR21 FR25	FR52 IE01 UKD IE02 FR41 FR24 FR26 UKK FR72
Intensive maize BOMEAT	Alpine	3	1	PT11	DE27 DE21
Intensive maize BOMEAT	Continental temperate	11	3	DE40 DE23 DE22	DEG0 AT12 DE26 DED0 DE24 DE80 DK DE25
Intensive maize BOMEAT	Mediterranean dry	2	1	ES70	CY
Intensive maize BOMEAT	Mediterranean wet	1	1	FR53	
Intensive maize BOMEAT	Oceanic temperate	38	9	NL34 NL12 DEA3 NL22 BE32 NL13 DE11 BE21 NL21	FR42 DE94 BE33 DEA1 NL11 DEA2 FR22 BE31 DEA4 BE22 NL42 NL33 DEB3 DE71 DEF0 LU00 BE23 BE35 DE93 DE91 NL41 BE24 NL23 NL31 NL32 DE12 BE25 FR30 DE92
No BOMEAT activity	Alpine	1	1	UKM	
No BOMEAT activity	Continental cold	3	1	EE	LV FI20
No BOMEAT activity	Continental temperate	2	1	CZ08	CZ01
No BOMEAT activity	Mediterranean dry	2	1	MT	PT30
No BOMEAT activity	Oceanic temperate	1	1	UKN	
Subsidiary Mediterranean BOMEAT	Continental temperate	24	6	PL32 DEE0 PL62 PL34 PL63 PL42	BG06 PL33 PL41 HU01 EL13 PL52 PL11 PL21 BG01 PL51 BG02 BG03 BG05 PL22 PL31 PL43 PL12 PL61
Subsidiary Mediterranean BOMEAT	Mediterranean dry	14	4	EL14 ES52 EL12 ES62	EL43 ES24 ES42 EL25 ES51 PT17 EL30 EL41 ES53 EL24
Subsidiary Mediterranean BOMEAT	Mediterranean wet	4	1	EL23	ITD5 EL11 EL22
Subsidiary Mediterranean BOMEAT	Oceanic temperate	1	1	FR10	
Subsidiary Nordic BOMEAT	Arctic	6	2	SE08 NO122	NO111 SE07 FI13 NO121
Subsidiary Nordic BOMEAT	Continental cold	3	1	NO231	FI19 SE06
Subsidiary Nordic BOMEAT	Continental temperate	1	1	SE09	
Subsidiary Nordic BOMEAT	Oceanic cold	4	1	NO242	NO241 NO243 NO252

Table 15: List of the leader regions per SHGOAT "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
Complement to bovine intensive SHGAOT	Alpine	8	2	ES11 AT31	FR43 DE13 DE21 SI DE27 DE14
Complement to bovine intensive SHGAOT	Arctic	2	1	FI13	NO233
Complement to bovine intensive SHGAOT	Continental cold	2	1	NO123	NO254
Complement to bovine intensive SHGAOT	Continental temperate	13	3	DK DE25 DE80	DE23 DED0 DE73 DE24 CZ01 DE40 DEG0 DE22 DE26 RO08
Complement to bovine intensive SHGAOT	Mediterranean dry	4	1	ES70	PT30 CY MT
Complement to bovine intensive SHGAOT	Mediterranean wet	3	1	ITD3	ITC4 ITC1
Complement to bovine intensive SHGAOT	Oceanic cold	1	1	NO244	
Complement to bovine intensive SHGAOT	Oceanic temperate	32	7	BE35 DEA4 DEA2 BE23 DEA5 DE11 BE21	FR23 BE24 DEB1 LU00 FR52 FR30 BE31 FR41 DEA3 FR25 DE71 BE32 BE22 DE92 BE33 DE72 DE94 DEF0 DE12 DEA1 FR22 DEC0 DE93 BE25 DE91
Complement to bovine mountainous SHGOAT	Alpine	6	2	AT33 ITD2	ES21 FR63 AT22 AT21
Complement to bovine mountainous SHGOAT	Continental temperate	2	1	SE09	BG04
Complement to bovine mountainous SHGOAT	Mediterranean dry	1	1	PT20	
Complement to bovine mountainous SHGOAT	Mediterranean wet	3	1	ES12	ITC3 ES13
Complement to bovine mountainous SHGOAT	Oceanic cold	2	1	AT32	AT34
Complement to bovine mountainous SHGOAT	Oceanic temperate	7	2	IE02 BE34	DEB2 UKN IE01 ITC2 FR72
Complement to dairy cattle Nordic SHGOAT	Arctic	5	2	SE08 NO122	SE07 NO111 NO121
Complement to dairy cattle Nordic SHGOAT	Continental cold	2	1	NO231	SE06
Complement to dairy cattle Nordic SHGOAT	Oceanic cold	4	1	NO241	NO242 NO243 NO252
Complement to granivores intensive SHGOAT	Alpine	3	1	PT11	SE0A ITD4
Complement to granivores intensive SHGOAT	Arctic	1	1	NO232	
Complement to granivores intensive SHGOAT	Continental cold	9	2	EE NO253	SE01 LT NO262 SE02 NO261 NO255 LV
Complement to granivores intensive SHGOAT	Continental temperate	51	12	BG05 RO01 AT11 BG03 PL32 HU07 CZ05 FR82 AT12 SE04 CZ07 PL34	PL21 PL11 CZ08 HU02 PL33 PL12 PL22 CZ02 RO04 CZ03 PL41 BG02 PL43 BG01 HU04 RO03 PL62 PL31 CZ04 RO06 PL51 PL63 RO07 RO02 HU06 CZ06 PL42 PL61 HU03 PL52 HU01 HU05 RO05 DEE0 BG06 SK03 SK01 SK04 SK02
Complement to granivores intensive SHGOAT	Mediterranean dry	14	4	ES51 FR83 ES24 PT15	ES52 ITG1 ES53 ITF4 ES23 ES30 PT18 PT17 ES62 ITF3
Complement to granivores intensive SHGOAT	Mediterranean wet	15	4	FR51 ITF5 ITF6 ITE2	ITD5 ITE4 FR61 ITF1 ES22 FR62 FR81 ITF2 ITE3 PT16 ITE1
Complement to granivores intensive SHGOAT	Oceanic cold	1	1	NO251	
Complement to granivores intensive SHGOAT	Oceanic temperate	7	2	FR42 FR71	FR24 FR10 DEB3 FR21 FR26
Mediterranean free-ranging SHGOAT	Continental temperate	1	1	EL13	
Mediterranean free-ranging SHGOAT	Mediterranean dry	13	3	ITG2 EL43 ES43	EL41 ES42 ES41 ES61 EL25 EL24 EL14 EL30 EL12 EL42
Mediterranean free-ranging SHGOAT	Mediterranean wet	5	2	EL22 FR53	EL23 EL21 EL11
No activity declared	Arctic	1	1	FI1A	
No activity declared	Continental cold	3	1	FI19	FI18 FI20
Temperate intensive indoor SHGOAT	Alpine	2	1	UKM	UKL
Temperate intensive indoor SHGOAT	Oceanic temperate	20	5	NL33 NL23 NL21 UKJ NL32	NL42 NL34 UKD NL13 UKH UKK UKC UKG UKF NL41NL12 NL22 NL31 NL11 UKE

Table 16: List of the leader regions per PORCIN "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
Common secondary intensive PORCIN	Alpine	11	3	FR43 ES21 AT33	ES11 DE21 FR63 AT21 DE27 DE14 AT31 DE13
Common secondary intensive PORCIN	Arctic	2	1	FI1A	FI13
Common secondary intensive PORCIN	Continental cold	3	1	FI20	FI19 FI18
Common secondary intensive PORCIN	Continental temperate	40	9	PL21 DE73 AT11 DE80 CZ06 DE24 DE26 DEG0 PL32	CZ08 DE40 PL52 PL43 PL62 CZ02 PL63 PL22 PL41 DE25 PL11 PL42 CZ01 PL34 PL33 CZ07 CZ05 PL51 PL61 CZ04 FR82 DE22 DE23 CZ03 PL31 DED0 DEE0 RO08 SK02 AT12 PL12
Common secondary intensive PORCIN	Mediterranean dry	16	4	ES52 PT17 PT30 PT15	ES24 ES30 ES41 ES61 ES42 FR83 ES23 MT ES70 ES53 ES43 CY
Common secondary intensive PORCIN	Mediterranean wet	9	2	PT16 FR51	FR81 FR53 ES22 ES12 FR61 ES13 FR62
Common secondary intensive PORCIN	Oceanic cold	2	1	AT34	AT32
Common secondary intensive PORCIN	Oceanic temperate	31	7	FR30 DE12 FR42 DE91 BE35 DE92 DEF0	DE71 FR72 DEA4 BE24 FR71 DEA1 BE31 FR24 DE72 BE32 DEA2 LU00 DEB2 UKH DE11 DEA5 BE34 DEB3 FR26 FR25 DEC0 DE93 DEB1BE33
Primary intensive with bovine PORCIN	Alpine	1	1	AT22	
Primary intensive with bovine PORCIN	Mediterranean dry	2	1	ES51	ES62
Primary intensive with bovine PORCIN	Oceanic temperate	8	2	NL41 NL22	BE21 BE22 NL42 NL21 DEA3 NL31
Secondary complement to grazing PORCIN	Alpine	3	1	PT11	UKL UKM
Secondary complement to grazing PORCIN	Arctic	5	2	NO122 NO233	NO232 NO111 NO121
Secondary complement to grazing PORCIN	Continental cold	8	2	NO253 NO254	NO255 NO261 NO123 NO262 NO231 EE
Secondary complement to grazing PORCIN	Continental temperate	4	1	SK04	SK01 SK03 EL13
Secondary complement to grazing PORCIN	Mediterranean dry	10	3	EL43 PT18 EL25	PT20 EL42 EL30 EL41 EL14 EL12 EL24
Secondary complement to grazing PORCIN	Mediterranean wet	4	1	EL23	EL22 EL11 EL21
Secondary complement to grazing PORCIN	Oceanic cold	6	2	NO242 NO241	NO243 NO252 NO244 NO251
Secondary complement to grazing PORCIN	Oceanic temperate	15	4	NL11 UKE NL23 NL12	UKD UKF IE01 NL32 UKK UKN NL33 IE02 NL34 UKG NL13
Secondary very intensive PORCIN	Alpine	2	1	ITD2	ITD4
Secondary very intensive PORCIN	Continental temperate	7	2	HU01 HU07	HU02 HU03 HU04 HU06 HU05
Secondary very intensive PORCIN	Mediterranean dry	4	1	ITG2	ITF3 ITF4 ITG1
Secondary very intensive PORCIN	Mediterranean wet	13	3	ITE4 ITC1 ITF5	ITE3 ITD5 ITE2 ITE1 ITD3 ITF1 ITF6 ITC4 ITC3 ITF2
Secondary very intensive PORCIN	Oceanic temperate	3	1	BE25	ITC2 BE23
Specialized PORCIN	Continental temperate	1	1	DK	
Specialized PORCIN	Oceanic temperate	2	1	FR52	DE94
Subsidiary intensive with crops PORCIN	Oceanic temperate	7	2	FR10 UKC	UKJ FR23 FR21 FR41 FR22
Subsidiary traditional PORCIN	Alpine	2	1	SI	SE0A
Subsidiary traditional PORCIN	Arctic	2	1	SE07	SE08
Subsidiary traditional PORCIN	Continental cold	5	2	LT SE02	LV SE06 SE01
Subsidiary traditional PORCIN	Continental temperate	15	4	SE04 RO04 BG03 RO05	SE09 BG05 BG02 RO07 RO02 RO01 RO06 BG01 BG06 BG04RO03

Table 17: List of the leader regions per LAHENS "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
No declared activity	Alpine	1	1	ITD2	
No declared activity	Arctic	3	1	NO122	NO121 NO111
No declared activity	Continental cold	1	1	NO255	
No declared activity	Mediterranean dry	2	1	PT30	PT20
No declared activity	Oceanic cold	4	1	NO251	NO242 NO252 NO241
No declared activity	Oceanic temperate	4	1	UKD	UKC UKJ UKH
Primary economically constrained LAHENS	Alpine	1	1	SI	
Primary economically constrained LAHENS	Continental cold	2	1	LV	LT
Primary economically constrained LAHENS	Continental temperate	31	7	RO02 PL63 RO03 PL32 RO07 BG01 RO06	RO08 PL51 PL31 RO05 PL62 BG02 BG04 PL11 RO01 BG03 BG05 PL42 PL33 EL13 RO04 PL61 BG06 PL41 PL12 PL52 PL34 PL43 PL22 PL21
Primary economically constrained LAHENS	Mediterranean dry	8	2	EL42 EL43	EL12 EL24 EL25 EL14 CY EL41
Primary economically constrained LAHENS	Mediterranean wet	3	1	EL11	EL23 EL22
Primary very dependent LAHENS	Alpine	3	1	UKL	UKM ITD4
Primary very dependent LAHENS	Arctic	1	1	NO232	
Primary very dependent LAHENS	Continental cold	4	1	NO261	NO254 NO253 NO262
Primary very dependent LAHENS	Continental temperate	10	3	HU06 HU05 HU02	HU01 HU03 SK01 SK03 HU07 SK02 SK04
Primary very dependent LAHENS	Mediterranean dry	8	2	EL30 ES41	ES70 ES53 ES30 ES61 MT ES42
Primary very dependent LAHENS	Mediterranean wet	12	3	ITC4 ITE3 FR51	ITD5 ES12 ITF1 ITC1 ITF2 EL21 ITD3 ES13 ITE2
Primary very dependent LAHENS	Oceanic cold	1	1	NO244	
Primary very dependent LAHENS	Oceanic temperate	18	4	UKE NL42 DE94 UKF	BE21 NL22 NL11 FR52 UKG NL12 UKN NL13 NL34 NL41 NL31 NL21 UKK NL23
Subsidiary climatically contrained LAHENS	Alpine	1	1	SE0A	
Subsidiary climatically contrained LAHENS	Arctic	2	1	SE07	SE08
Subsidiary climatically contrained LAHENS	Continental cold	3	1	SE02	SE01 SE06
Subsidiary climatically contrained LAHENS	Continental temperate	2	1	SE04	SE09
Subsidiary common intensive LAHENS	Alpine	12	3	ES21 ES11 AT31	AT21 DE21 DE27 AT22 FR63 PT11 DE14 DE13 AT33
Subsidiary common intensive LAHENS	Arctic	3	1	NO233	FI1A FI13
Subsidiary common intensive LAHENS	Continental cold	6	2	NO231 FI19	FI20 FI18 NO123 EE
Subsidiary common intensive LAHENS	Continental temperate	23	6	CZ04 DED0 HU04 CZ02 AT12 DE23	DK DE26 DE80 DEE0 AT11 CZ08 DEG0 FR82 DE25 CZ03 DE22 DE24 DE40 DE73 CZ06 CZ05 CZ07
Subsidiary common intensive LAHENS	Mediterranean dry	13	3	ES52 ES43 ES23	ES24 ES51 PT17 ITG2 PT18 ITF4 ITG1 ES62 ITF3 PT15
Subsidiary common intensive LAHENS	Mediterranean wet	9	2	PT16 ITE1	ES22 ITF6 FR81 ITF5 FR61 ITC3 ITE4
Subsidiary common intensive LAHENS	Oceanic cold	3	1	AT32	NO243 AT34
Subsidiary common intensive LAHENS	Oceanic temperate	37	9	NL33 FR42 DE12 BE24 ITC2 DEA3 DEA4 DE11 DE92	DE91 DE72 FR72 FR25 IE02 BE31 DEB2 BE25 FR71 DEA1 DEF0 BE22 FR30 DEB3 DE93 BE34 DEC0 LU00 NL32 BE33 IE01 DEA5 BE32 BE23 DEA2 DE71 DEB1 BE35
Subsidiary complement to crops LAHENS	Alpine	1	1	FR43	
Subsidiary complement to crops LAHENS	Continental temperate	1	1	CZ01	
Subsidiary complement to crops LAHENS	Mediterranean dry	3	1	FR83	FR53 FR62
Subsidiary complement to crops LAHENS	Oceanic temperate	7	2	FR22 FR26	FR10 FR23 FR21 FR24 FR41

Table 18: List of the leader regions per POUFAT "climate * LPS" association to be surveyed

LPS	Climates	No regions per association	No. regions to be sampled	Leader regions	Other regions
No activity declared	Alpine	1	1	ITD2	
No activity declared	Arctic	3	1	NO122	NO111 NO121
No activity declared	Mediterranean dry	2	1	PT30	PT20
No activity declared	Oceanic cold	2	1	NO241	NO252
No activity declared	Oceanic temperate	4	1	UKH	UKC UKD UKJ
Primary very intensive POUFAT	Alpine	3	1	ITD4	UKM UKL
Primary very intensive POUFAT	Continental temperate	6	2	HU02 HU05	HU03 HU06 HU01 HU07
Primary very intensive POUFAT	Mediterranean dry	4	1	ES61	ES41 ES42 ES30
Primary very intensive POUFAT	Mediterranean wet	9	2	FR51 ITD5	ITD3 ITC4 ITF2 ITE3 ITE2 FR61 ITC1
Primary very intensive POUFAT	Oceanic temperate	8	2	UKN UKK	UKG UKE DE94 UKF FR52 FR71
Secondary very dependent Canarias POUFAT	Mediterranean dry	1	1	ES70	
Subsidiary constrained intensive POUFAT	Alpine	1	1	PT11	
Subsidiary constrained intensive POUFAT	Arctic	4	1	NO233	FI13 FI1A NO232
Subsidiary constrained intensive POUFAT	Continental cold	12	3	FI19 EE NO255	NO253 NO231 LV FI18 NO254 NO261 NO262 FI20 NO123
Subsidiary constrained intensive POUFAT	Continental temperate	21	5	DK RO08 CZ01 CZ03 SK01	SK04 RO03 RO01 CZ04 RO02 RO04 CZ02 CZ06 RO05 SK02 CZ05 RO06 CZ07 CZ08 SK03 RO07
Subsidiary constrained intensive POUFAT	Mediterranean dry	3	1	PT18	PT15 PT17
Subsidiary constrained intensive POUFAT	Mediterranean wet	1	1	PT16	
Subsidiary constrained intensive POUFAT	Oceanic cold	4	1	NO251	NO244 NO242 NO243
Subsidiary constrained intensive POUFAT	Oceanic temperate	2	1	IE02	IE01
Subsidiary constrained natural rhythm POUFAT	Alpine	9	2	AT21 AT31	DE27 AT33 DE21 DE14 DE13 AT22 SE0A
Subsidiary constrained natural rhythm POUFAT	Arctic	2	1	SE08	SE07
Subsidiary constrained natural rhythm POUFAT	Continental cold	4	1	LT	SE02 SE01 SE06
Subsidiary constrained natural rhythm POUFAT	Continental temperate	37	9	DE73 AT12 DEG0 BG03 DE24 PL21 PL62 DE22 DE25	PL52 SE04 DE80 PL32 BG05 BG06 PL11 BG01 PL22 DE26 PL43 PL42 PL12 DE40 SE09 BG04 PL34 PL51 PL61 PL31 AT11 PL63 DED0 DE23 PL33 DEE0 PL41 BG02
Subsidiary constrained natural rhythm POUFAT	Mediterranean dry	5	2	ITF3 ITG1	ITG2 CY ITF4
Subsidiary constrained natural rhythm POUFAT	Mediterranean wet	6	2	ITC3 ITF1	ITF6 ITE4 ITF5 ITE1
Subsidiary constrained natural rhythm POUFAT	Oceanic cold	2	1	AT32	AT34
Subsidiary constrained natural rhythm POUFAT	Oceanic temperate	18	4	DEA2 DE71 DEA1 DEF0	DE93 DEB1 DEA5 DEB3 DE91 DEC0 ITC2 DEA3 DE92 DE12 DEA4 DE72 DEB2 DE11
Subsidiary very dependent POUFAT	Oceanic temperate	12	3	NL32 NL22 NL41	NL13 NL21 NL31 NL12 NL42 NL23 NL33 NL34 NL11
Subsidiary with cattle intensive POUFAT	Alpine	4	1	SI	FR63 ES11 ES21
Subsidiary with cattle intensive POUFAT	Continental temperate	3	1	EL13	HU04 FR82
Subsidiary with cattle intensive POUFAT	Mediterranean dry	16	4	EL25 ES52 EL12 ES23	ES43 ES62 ES24 EL30 EL42 EL41 MT ES53 EL14 EL24 ES51 EL43
Subsidiary with cattle intensive POUFAT	Mediterranean wet	8	2	ES12 FR81	EL22 EL23 ES22 EL21 EL11 ES13
Subsidiary with cattle intensive POUFAT	Oceanic temperate	15	4	FR25 LU00 BE22 BE32	BE34 BE25 BE24 BE33 FR42 BE23 BE31 FR72 BE35 FR30 BE21
Subsidiary with cattle very intensive POUFAT	Alpine	1	1	FR43	
Subsidiary with cattle very intensive POUFAT	Mediterranean dry	1	1	FR83	
Subsidiary with cattle very intensive POUFAT	Mediterranean wet	2	1	FR53	FR62
Subsidiary with cattle very intensive POUFAT	Oceanic temperate	7	2	FR23 FR22	FR21 FR10 FR26 FR41 FR24

9. Final conclusions

The aim of this study was to zone Livestock Production Systems existing of the six main livestock sectors in Europe and Norway: the dairy cows (BOMILK), the cattle rearing and fattening (BOMEAT), the sheep's and goats activities for milk as well for meat (SHGOAT), the rearing and fattening of pigs (PROCIN), the eggs production (LAHENS) and the meat production from broilers (POUFAT). This six livestock sectors were described from a set of variables extracted from the CAPRI Modelling System for year 2002 (the baseline year). The statistical classification of the livestock sectors allowed us to identify and suggest a set of LPS per livestock sector at regional level according to few livestock production dimensions:

- the feeding strategy
- the level of intensification of the production
- the keeping strategy
- the dependence on the market for feedstuffs supplies
- and the economic importance of a livestock sector

By having recourse to external to CAPRI datasets such as Eurostat farm types or again JRC Agri4cast meteorological database and profile of animals assemblages, we have been able to cross-validate and propose effective description of every one of the LPS identified. Then, by livestock sector, mapping of the main LPS identified has been done and a sampling proposed to perform survey on LPS related manures management practices in vigour in EU27 and Norway.

From the forthcoming survey, we expect to complete the scientific and expert knowledge concerning the manures management strategies set up in respect to the LPS retained on farm. A better understanding of the link between main LPS and main manures management strategies should ease the building of a multidimensional and complete LPS typology in the next future. However, if the dimensions retained appeared as effective to correctly describe LPS, certain lack of knowledge or certain limits to our approach have been observed; the identification and further the understanding of these limits would allow us to perform the next LPS typology as expected in the GGELS project.

We showed that an important source of differentiation of the LPS was coming from the feeding strategy and more particularly from the relationship existing between regional livestock requirements for energy and protein and the potential supply of energy and protein from the local crops i.e. the autonomy level. Autonomy level of a region was based on (i) the regionalized crops share processed by CAPRI from national statistics and Corinne Land Cover, (ii) the crop productions registered and provided by national authorities, (iii) the attribution of crops production according to animals feeding requirements without a clear knowledge of the proportion homegrown and auto-consumed per region. To make effective the next LPS typology, many aspects of the feeding strategy have to be deeply analysed:

- The attribution of certain cereals and rich protein crops to feed monogastric animals was partly subjective and didn't correspond fully to the real practices. Other data concerning the feedstuffs composition and provision per livestock sector should be considered – some databases describing the main crop products used for the preparation of the feedstuffs are already available on-line[22].
- Autonomy level was considered as a proportion of the animals requirements being potentially fulfilled from the cultivated crops and fodders. However, never information concerning the real

[22] For instance, the French institute of agriculture statistics, AGRESTE, delivers statistics on the regional feedstuffs composition
http://agreste.agriculture.gouv.fr/publications_2/chiffres_donnees_56/premieres_alimentation_3825.html

share of the homegrown and auto-consumed plant productions have been considered; only intensification as the investment for feedstuffs and veterinary products provision was used as a proxy. Effective approach should consider or model the real proportion of feedstuffs produced and used on farm together with the proportion of purchased feedstuffs (Kristensen et al., 2005; Dalgaard et al., 2006).

- To determine the level of dependence to the market of a LPS, we considered the energy and protein (and fibbers) autonomy. However, calculation were done from CAPRI dataset and no verification of the data was made before processing classification. One solution could be the use of more accurate values of the regional grassland productivity as proposed by Smit et al. (2008) to decide of the correctness to use CAPRI values.

But other dimensions considered in the study are suffering of subjectivity or imprecision. The best example concerned the keeping strategy of grazing livestock interpreted from the variables available in CAPRI. As mentioned for the description of the classes, modalities of the keeping strategy have been proposed by the author as “possible” strategies and decided from his own experience of functioning of LPS; from this, they cannot be considered as true strategies and one could interpret differently the results of the classification. To avoid misunderstanding and inconsistency when integrating keeping dimension within the next LPS typology, we planned to have recourse to expert’s network to verify the interpretation made of the diverse LPS. Partnership with Institut de l’Elevage in France has been initially thought to provide expertise to the GGELS responsible as well as to actively participate to the building of the LPS typology. Together with Institut de l’Elevage, yearly and daily grazing period duration could be assessed or even modelled; silage practices could also be decided and integrated as classifiers when processing the LPS typology.

Other contact with MATRESA experts concerned by manures management practices (a dimension to integrate to the typology after obtaining of the results from the survey) or COPA-COGECA[23] should allow us to provide suitable LPS typology.

Finally, concerning the sampling design and size proposed, it has been done according to well accepted probabilistic requirements allowing surveyors to obtain significant and representative results. Survey having to be performed by national experts, the sampling has been decided independently of any risk of overloading (too much regions in a Member State to be surveyed and consequently too much work for one single national expert). If some regions or some European Member States appeared as overloaded, contractor responsible of the survey could envisage changing the lists of regions to be surveyed in the way to reduce work for each expert. If a certain flexibity to inter-change one region by another of the same “LPS*climate” association exists, it should be done respectively to the minimum number of regions to be surveyed we proposed. If decision would be taken to reduce the number of regions, it should be decided altogether after an ex-ante evaluation of the consequences on the expected accuracy and representativeness of the results obtained from a restrained sample.

[23] http://www.copa-cogeca.be/Main.aspx?page=HomePage

Annex 1. List of the variables obtained or calculated from 2002CAPRI baseline (per region)

Variables	Categories of descriptors	Description	Units
NUTS0_cod	Regions identification	Acronym of the country	(na)[(i)]
NUTS2_cod	Regions identification	Acronym of the region	(na)
NUT2_names	Regions identification	Name of the region	(na)
BOMILK_heads [(ii)]	Animal numbers	True number of heads for BOMILK sector	head
BOMILK_Lutot	Animal numbers	True number of livestock units for BOMILK sector	LU (livestock unit)
BOMILK_sqrt(LU+1)	Animal numbers	Root square (the true number of livestock unit for BOMILK sector + 1)	LU (livestock unit)
NMDS_sqrt(LU+1)_axe1	Animal numbers	Region coordinate on axe 1 from the Non-Metric multiDimensional Scaling used to class animals assemblages	(na)
NMDS_sqrt(LU+1)_axe2	Animal numbers	Region coordinate on axe 2 from the Non-Metric multiDimensional Scaling used to class animals assemblages	(na)
NMDS_sqrt(LU+1)_axe3	Animal numbers	Region coordinate on axe 3 from the Non-Metric multiDimensional Scaling used to class animals assemblages	(na)
ACP_sqrt(LU+1)_comp1	Animal numbers	Region coordinate on component 1 from the Principal Component Analysis used to class animals assemblages	(na)
ACP_sqrt(LU+1)_comp2	Animal numbers	Region coordinate on component 2 from the Principal Component Analysis used to class animals assemblages	(na)
ACP_sqrt(LU+1)_comp3	Animal numbers	Region coordinate on component 3 from the Principal Component Analysis used to class animals assemblages	(na)
BOMILK_intensification_€/LU	Intensification	Total costs dedicated to the use of feedstuffs and veterinary products per livestock unit in a year	€.LU-1
BOMILK_intensification_€/hd	Intensification	Total costs dedicated to the use of feedstuffs	€.head-1

		and veterinary products per head in a year	
BOMILK_intensification_%	Intensification	Proportion of total costs per activity dedicated to the use of feedstuffs and veterinary products per livestock unit in a year	%
DIV_margaleff	Animals assemblages	Margaleff index of diversity	(na)
DIV_MacIntosh	Animals assemblages	Mac Intosh index of diversity	(na)
DIV_Shannon	Animals assemblages	Shannon index of diversity	(na)
DIV_Simpson	Animals assemblages	Simpson index of diversity	(na)
EVEN_MacIntosh	Animals assemblages	Mac Intosh index of evenness	(na)
EVEN_shannon	Animals assemblages	Shannon index of evenness	(na)
Freez_day	Climate	Averages number of freezing days a year (from 1998-2007 observations)	days
Snow_day	Climate	Averages number of snowy days a year (from 1998-2007 observations)	days
Rain_day	Climate	Averages number of rainy days a year (from 1998-2007 observations)	days
Rainfal_3(mm)	Climate	Cumulative precipitation over the first three months (from 1998-2007 observations)	mm
Rainfal_6(mm)	Climate	Cumulative precipitation over the first six months (from 1998-2007 observations)	mm
Rainfal_12(mm)	Climate	Cumulative precipitation over the year (from 1998-2007 observations)	mm
PAR_3_(MJ/m2)	Climate	Cumulative photosynthetic active radiation over the first three months (from 1998-2007 observations)	MJ.m-2
PAR_6_(MJ/m2)	Climate	Cumulative photosynthetic active radiation over the first six months (from 1998-2007 observations)	MJ.m-2
PAR_12_(MJ/m2)	Climate	Cumulative	MJ.m-2

		photosynthetic active radiation over year (from 1998-2007 observations)	
Tcum_3(°C.d)	Climate	Averaged cumulative daily temperature for the first three months (from 1998-2007 observations)	°C.day-1 (base temperature = 0°C)
Tcum_6(°C.d)	Climate	Averaged cumulative daily temperature for the first six months (from 1998-2007 observations)	°C.day-1 (base temperature = 0°C)
Tcum_12(°C.d)	Climate	Averaged cumulative daily temperature over the year (from 1998-2007 observations)	°C.day-1 (base temperature = 0°C)
Tmoy_3(°C)	Climate	Averaged daily temperature for the first three months (from 1998-2007 observations)	°C
Tmoy_6(°C)	Climate	Averaged daily temperature for the first six months (from 1998-2007 observations)	°C
Tmoy_12(°C)	Climate	Averaged daily temperature over the year (from 1998-2007 observations)	°C
Elevation_moy(m)	Climate	Averaged elevation from a 1*1 km grid	m
Typ_41_cattll_dairy(%)	Farm type	Proportion of farm type 41 (dairy cattle) in a region	%
Typ_42_cattl_rear_fat(%)	Farm type	Proportion of farm type 42 (rearing/fattening cattle) in a region	%
Typ_43_cattl_dairy_rear_fat(%)	Farm type	Proportion of farm type 43 (dairy and rearing/fattening cattle) in a region	%
Typ_44_SHGOAT_othgraz(%)	Farm type	Proportion of farm type 44 (Sheep and goats + other grazing livestock) in a region	%
Typ_50_granivor(%)	Farm type	Proportion of farm type 50 (granivore) in a region	%
Typ_71_mixed_graz++(%)	Farm type	Proportion of farm type 71 (mixed grazing livestock) in a region	%
Typ_72_mixed_granivor++(%)	Farm type	Proportion of farm type 72 (mixed granivore livestock) in a region	%
Typ_81_crop+graz(%)	Farm type	Proportion of farm type 81 (annual crops and	%

		grazing livestock) in a region	
Typ_82_crops+livestock(%)	Farm type	Proportion of farm type 82 (annual crops and livestock) in a region	%
Typ_LPS/Total(%)	Farm type	Proportion of farms with livestock production (all sector confounded) in a region	%
UAAtot_calculée	Cropping system	Total used arable area	ha
Cereals(ha)[iii]	Cropping system	Total UAA dedicated to wheat (soft + durum)	Ha
Cereals(%)	Cropping system	Proportion of the total UAA dedicated to wheat (soft + durum)	%
Stocking_density (grazingLU/ha)	Intensification	Number of grazing livestock per hectare of fodder activities	$LU.ha^{-1}$
Stocking_density (allLU/ha)	Intensification	Number of livestock per hectare of fodder activities	$LU.ha^{-1}$
Revenues_Cereals(€)	Production	Total revenues of the cereals' activities	€
Revenues_Cereals(%)	Production	Proportion of the total crops revenues coming from the cereals' activities	%
Revenues_BOMILK(€)	Production	Total revenues of the BOMILK activity	€
Revenues_BOMILK(%)	Production	Proportion of the total livestock revenue coming from the BOMILK activity	%
REVENUE_CROPS(€)	Production	Total revenue of crops	€
Revenues_ANIMAL(€)	Production	Total revenue of livestock	€
Revenues_AGRICULTURE(€)	Production	Total revenue of Agriculture	€
Revenues_CROPS(%oftot)	Production	Proportion of the total agriculture revenue from crops	%
Revenues_ANIMAL(%oftot)	Production	Proportion of the total agriculture revenue from livestock	%
NRJ_Autonomy_fodgras (%)	Feeding strategy	Proportion of the grazing livestock energy requirements a year covered by the grasses production	%
NRJ_Autonomy_fodgras+maiz (%)	Feeding strategy	Proportion of the grazing livestock energy requirements a year covered by the grasses + fodder maize production	%
NRJ_Autonomy_fodall (%)	Feeding strategy	Proportion of the grazing livestock energy requirements a	%

		year covered by the fodders production	
PROT_Autonomy_fodgras (%)	Feeding strategy	Proportion of the grazing livestock protein requirements a year covered by the grasses production	%
PROT_Autonomy_fodgras+maiz (%)	Feeding strategy	Proportion of the grazing livestock protein requirements a year covered by the grasses + fodder maize production	%
PROT_Autonomy_fodall (%)	Feeding strategy	Proportion of the grazing livestock protein requirements a year covered by the fodders production	%
GrazingLU_NRJtot_requirement_(MJ/year)	Feeding strategy	Total energy requirement a year for all grazing livestock	$MJ.year^{-1}$
GrazingLU_PROTtot_requirement_(MJ/year)	Feeding strategy	Total protein requirement a year for all grazing livestock	$kg.year^{-1}$
Monogastric_Lysdig_autosufficency(%)	Feeding strategy	Proportion of the granivores digestible lysine requirements a year covered by the rich protein crops + wheat + barley	%
PORCIN_Lysdig_(kg/year)	Feeding strategy	Total digestible lysine requirements for pigs production	$kg.year^{-1}$
POUFAT_Lysdig_(kg/year)	Feeding strategy	Total digestible lysine requirements for poultry for fattening production	$kg.year^{-1}$
LAHENS_Lysdig_(kg/year)	Feeding strategy	Total digestible lysine requirements for laying hens production	$kg.year^{-1}$
BOMILK_Production(liters) [(iv)]	Production	Total BOMILK production a year	l (milk) tons (meat) tons (eggs)
DCOH_prod(liter/head) [(v)]	Production	Milk yield from dairy cow “high yield”	$l.head^{-1}$ (milk) $kg.head^{-1}$ (carcass weight or eggs produced)
Manure_BOMILK_N(Kg)	Manure production	Total quantity of nitrogen in manure from BOMILK a year	kg
Manure_BOMILK_P(Kg)	Manure production	Total quantity of phosphorus in manure from BOMILK a year	kg
Manure_BOMILK_K(Kg)	Manure production	Total quantity of potassium in manure from BOMILK a year	kg

Manure_BOMILK_N(%)	Manure production	Proportion of total quantity of nitrogen in manure coming from BOMILK a year	%
Manure_BOMILK_P(%)	Manure production	Proportion of total quantity of phosphorus in manure coming from BOMILK a year	%
Manure_BOMILK_K(%)	Manure production	Proportion of total quantity of potassium in manure coming from BOMILK a year	%
Ntot_kg/ha	Manure production	Total quantity of nitrogen used per hectare (fertilizer + residues + manure)	$kg.ha^{-1}$
%_Nmanure	Manure production	Proportion of the total nitrogen used per hectare coming from manures	%
Ptot_kg/ha	Manure production	Total quantity of phosphorus used per hectare (fertilizer + residues + manure)	$kg.ha^{-1}$
%_Pmanure	Manure production	Proportion of the total phosphorus used per hectare coming from manures	%
Ktot_kg/ha	Manure production	Total quantity of potassium used per hectare (fertilizer + residues + manure)	$kg.ha^{-1}$
%_Kmanure	Manure production	Proportion of the total potassium used per hectare coming from manures	%
Nsurplus_sol(kg/ha)	Environmental impact	Total nitrogen surplus at soil level (after run off)	$kg.ha^{-1}$
Nsurplus_tot(kg/ha)	Environmental impact	Total nitrogen surplus	$kg.ha^{-1}$
Psurplus_sol(kg/ha)	Environmental impact	Total potassium surplus at soil level (after run off)	$kg.ha^{-1}$
Psurplus_tot(kg/ha)	Environmental impact	Total potassium surplus	$kg.ha^{-1}$
Ksurplus_sol(kg/ha)	Environmental impact	Total phosphorus surplus at soil level (after run off)	$kg.ha^{-1}$
Ksurplus_tot(kg/ha)	Environmental impact	Total phosphorus surplus	$kg.ha^{-1}$

[i] *(na) = non applicable*

[ii] *Six different livestock sectors have been considered: BOMILK (cattle milk production), BOMEAT (cattle meat production), SHGOAT (ovine milk and meat production), PORCIN (pig meat production and pig rearing activities), LAHENS (laying hens) and POUFAT (meat from poultry) – variables are explained for BOMILK only.*

[iii] Crops have been grouped into eight different activities of crop production: Cereals, Fodder, Oilseeds, Pulses, Roots, Set aside and fallow lands, Vegetables and permanent crops, all remaining area are grouped inside a Rest category – variables are explained for Cereals only.
[iv] Total quantities produced a year are given for BOMILK, BOMEAT, POUFAT, LAHENS, PORCIN and separately SHGOAT-meat and SHGOAT-milk
[v] Production as a yield is given for more numerous livestock activities: DCOH, dairy cow high yield – DCOL, dairy cow low yield – SCOW, suckler cow – CAFF, female calf for fattening – CAMF, male calf for fattening – HEIH, heifer for fattening high yield – HEIL, heifer for fattening low yield – BULH, bull for fattening high yield – BULL, bull for fattening low yield – HENS, laying hens (eggs production) – POUF, poultry for fattening – PIGF, pig for fattening – SHGMILK, sheep and goat for milk – SHGFAT, sheep and goat for fattening.

Annex 2. List of the different "regions" that the CAPRI Modelling System is using

NUTS0	NUTS2	NUTS2_names
AT	**AT11**	**Burgenland**
AT	**AT12**	**Niederoesterreich**
AT	**AT21**	**Kaernten**
AT	**AT22**	**Steiermark**
AT	**AT31**	**Oberoesterreich**
AT	**AT32**	**Salzburg**
AT	**AT33**	**Tirol**
AT	**AT34**	**Vorarlberg**
BE	**BE21**	**Antwerpen**
BE	**BE22**	**Limburg (B)**
BE	**BE23**	**Oost-Vlaanderen**
BE	**BE24**	**Vlaams Brabant**
BE	**BE25**	**Weat-Vlaanderen**
BE	**BE31**	**Brabant Wallon**
BE	**BE32**	**Hainaut**
BE	**BE33**	**Liege**
BE	**BE34**	**Luxembourg (B)**
BE	**BE35**	**Nmanur**
BG	**BG01**	**Severozapaden**
BG	**BG02**	**Severen tsentralen**
BG	**BG03**	**Severoiztochen**
BG	**BG04**	**Yugozapaden**
BG	**BG05**	**Yuzhen tsentralen**
BG	**BG06**	**Yugoiztochen**
CY	**CY**	**Cyprus**
CZ	**CZ01**	**Praha**
CZ	**CZ02**	**Strednφ Cechy**
CZ	**CZ03**	**Jihozßpad**
CZ	**CZ04**	**Severozßpad**
CZ	**CZ05**	**Severov²chod**
CZ	**CZ06**	**Jihov²chod**
CZ	**CZ07**	**Strednφ Morava**
CZ	**CZ08**	**Moravskoslezko**
DE	**DE11**	**Stuttgart**
DE	**DE12**	**Karlsruhe**
DE	**DE13**	**Freiburg**
DE	**DE14**	**Tuebingen**
DE	**DE21**	**Oberbayern**
DE	**DE22**	**Niederbayern**
DE	**DE23**	**Oberpfalz**
DE	**DE24**	**Oberfranken**
DE	**DE25**	**Mittelfranken**
DE	**DE26**	**Unterfranken**
DE	**DE27**	**Schwaben**
DE	**DE40**	**Brandenburg**
DE	**DE71**	**Darmstadt**
DE	**DE72**	**Giessen**
DE	**DE73**	**Kassel**
DE	**DE80**	**Mecklenburg-vorpommern**
DE	**DE91**	**Braunschweig**
DE	**DE92**	**Hannover**
DE	**DE93**	**Lueneburg**
DE	**DE94**	**Weser-Ems**
DE	**DEA1**	**Duesseldorf**
DE	**DEA2**	**Koeln**
DE	**DEA3**	**Muenster**
DE	**DEA4**	**Detmold**
DE	**DEA5**	**Arnsberg**
DE	**DEB1**	**Koblenz**
DE	**DEB2**	**Trier**
DE	**DEB3**	**Rheinhessen-Pfalz**
DE	**DEC0**	**Saarland**
DE	**DED0**	**Sachsen**
DE	**DEE0**	**Sachsen-Anhalt**
DE	**DEF0**	**Schleswig-Holstein**
DE	**DEG0**	**Thueringen**
DK	**DK**	**Danmark**
EE	**EE**	**Estonia**
EL	**EL11**	**Anatoliki makedonia**
EL	**EL12**	**Kentriki makedonia**
EL	**EL13**	**Dytiki makedonia**
EL	**EL14**	**Thessalia**
EL	**EL21**	**Ipeiros**
EL	**EL22**	**Ionia nisia**
EL	**EL23**	**Dytiki ellada**
EL	**EL24**	**Sterea ellada**
EL	**EL25**	**Peloponnisos**
EL	**EL30**	**Attiki**
EL	**EL41**	**Voreio aigaio**
EL	**EL42**	**Notio aigaio**
EL	**EL43**	**Kriti**
ES	**ES11**	**Galicia**
ES	**ES12**	**Asturias**
ES	**ES13**	**Cantabria**
ES	**ES21**	**Pais vasco**
ES	**ES22**	**Navarra**
ES	**ES23**	**Rioja**
ES	**ES24**	**Aragon**
ES	**ES30**	**Communidad de Madrid**
ES	**ES41**	**Castilla-Leon**
ES	**ES42**	**Castilla-la Mancha**
ES	**ES43**	**Extremadura**
ES	**ES51**	**Cataluna**
ES	**ES52**	**Comunidad Valenciana**
ES	**ES53**	**Baleares**
ES	**ES61**	**Andalucia**
ES	**ES62**	**Murcia**
ES	**ES70**	**Canarias**
FI	**FI13**	**Itae-Suomi**
FI	**FI18**	**Laensi-Suomi**
FI	**FI19**	**Pohjois-Suomi**
FI	**FI1A**	**Etelae-Suomi**
FI	**FI20**	**Ahvenanmaa/Aaland**
FR	**FR10**	**Ile de france**
FR	**FR21**	**Champagne-Ardenne**
FR	**FR22**	**Picardie**
FR	**FR23**	**Haute-Normandie**
FR	**FR24**	**Centre**
FR	**FR25**	**Basse-Normandie**
FR	**FR26**	**Bourgogne**
FR	**FR30**	**Nord-Pas-De-Calais**
FR	**FR41**	**Lorraine**
FR	**FR42**	**Alsace**
FR	**FR43**	**Franche-Comte**
FR	**FR51**	**Pays de la loire**
FR	**FR52**	**Bretagne**
FR	**FR53**	**Poitou-Charentes**
FR	**FR61**	**Aquitaine**
FR	**FR62**	**Midi-Pyrenees**
FR	**FR63**	**Limousin**
FR	**FR71**	**Rhone-Alpes**
FR	**FR72**	**Auvergne**
FR	**FR81**	**Languedoc-Roussillon**
FR	**FR82**	**Provence-Alpes-Cote dAzur**
FR	**FR83**	**Corse**
HU	**HU01**	**Közép-Magyarország**
HU	**HU02**	**Közép-Dunántúl**
HU	**HU03**	**Nyugat-Dunántúl**
HU	**HU04**	**Dél-Dunántúl**
HU	**HU05**	**Észak-Magyarország**
HU	**HU06**	**Észak-Alföld**
HU	**HU07**	**Dél-Alföld**
IE	**IE01**	**Border**
IE	**IE02**	**Southern and Eastern**
IT	**ITC1**	**Piemonte**
IT	**ITC2**	**Valle dAosta**
IT	**ITC3**	**Liguria**
IT	**ITC4**	**Lombardia**
IT	**ITD2**	**Trentino-Alto Adige**
IT	**ITD3**	**Veneto**
IT	**ITD4**	**Friuli-Venezia Giulia**
IT	**ITD5**	**Emilia-Romagna**
IT	**ITE1**	**Toscana**

IT	ITE2	Umbria
IT	ITE3	Marche
IT	ITE4	Lazio
IT	ITF1	Abruzzo
IT	ITF2	Molise
IT	ITF3	Campania
IT	ITF4	Puglia
IT	ITF5	Basilicata
IT	ITF6	Calabria
IT	ITG1	Sicilia
IT	ITG2	Sardegna
LT	LT	Lithuania
LU	LU00	Luxembourg (Grand-Duche)
LV	LV	Latvia
MT	MT	Malta
NL	NL11	Groningen
NL	NL12	Friesland
NL	NL13	Drenthe
NL	NL21	Overijssel
NL	NL22	Gelderland
NL	NL23	Flevoland
NL	NL31	Utrecht
NL	NL32	Noord-Holland
NL	NL33	Zuid-Holland
NL	NL34	Zeeland
NL	NL41	Noord-Brabant
NL	NL42	Limburg (NL)
NO	NO111	Finnmark
NO	NO121	Troms
NO	NO122	Nordland
NO	NO123	Nord-Troendelag
NO	NO231	Soer-Troendelag
NO	NO232	Hedmark
NO	NO233	Oppland
NO	NO241	Moere og Romsdal
NO	NO242	Sogn og Fjordane
NO	NO243	Hordaland
NO	NO244	Rogaland
NO	NO251	Aust-Agder
NO	NO252	Vest-Agder
NO	NO253	Telemark
NO	NO254	Vestfold
NO	NO255	Buskerud
NO	NO261	Oslo og Akershus
NO	NO262	Oestfold
PL	PL11	L≤dzkie
PL	PL12	Mazowieckie
PL	PL21	Malopolskie
PL	PL22	Slaskie
PL	PL31	Lubelskie
PL	PL32	Podkarpackie
PL	PL33	Swietokrzyskie
PL	PL34	Podlaskie
PL	PL41	Wielkopolskie
PL	PL42	Zachodniopomorskie
PL	PL43	Lubuskie
PL	PL51	Dolnoslaskie
PL	PL52	Opolskie
PL	PL61	Kujawsko-Pomorskie
PL	PL62	Warminsko-Mazurskie
PL	PL63	Pomorskie
PT	PT11	Norte
PT	PT15	Algarve
PT	PT16	Centro
PT	PT17	Lisboa
PT	PT18	Alentejo
PT	PT20	Acores
PT	PT30	Madeira
RO	RO01	Nord-Est
RO	RO02	Sud-Est
RO	RO03	Sud
RO	RO04	Sud-Vest
RO	RO05	Vest
RO	RO06	Nord-Vest
RO	RO07	Centru
RO	RO08	Bucuresti
SE	SE01	Stockholm
SE	SE02	Oestra mellansverige
SE	SE04	Sydsverige
SE	SE06	Norra mellansverige
SE	SE07	Mellersta norrland
SE	SE08	Oevre norrland
SE	SE09	Smaaland med Oearna
SE	SE0A	Vaestsverige
SI	SI	Slovenia
SK	SK01	Bratislavský kraj
SK	SK02	Západné Slovensko
SK	SK03	Stredné Slovensko
SK	SK04	Východné Slovensko
UK	UKC	North East
UK	UKD	North West (including Merseyside)
UK	UKE	Yorkshire and The Humber
UK	UKF	East Midlands
UK	UKG	West Midlands
UK	UKH	Eastern
UK	UKJ	South East
UK	UKK	South West
UK	UKL	Wales
UK	UKM	Scotland
UK	UKN	Northern Ireland

Annex 3: Results of the analyse of variance applied to the main descriptive variables of the 8 climatic clusters in EU25 + Norway

Clusters	(n)	No. freezing days			No. rainy days			Rainfall (mm/12months)			Cum T° (°C.d^{-1}/6months)			PAR ($MJ.m^{-2}$)		
Cluster 1	66	17.4	10.1	f	96.3	11.1	b	827.5	91.2	c	1697.7	103.8	c	9.9	0.9	d
Cluster 2	8	78.5	12.7	c	113.9	7.3	a	1278.7	147.4	a	988.9	251	e	8.6	1.6	ef
Cluster 3	32	2.8	3	g	41.9	7	f	482.2	91.4	f	2544.9	248.4	a	15.9	1.6	a
Cluster 4	67	50.4	12.8	d	69.2	11.4	d	632.1	70.7	e	1622	212.9	d	11.1	1.4	c
Cluster 5	16	97	15.8	b	83.9	12.7	c	711.6	125.6	d	965	149.1	e	8.8	0.8	e
Cluster 6	26	7.1	5.3	g	61.7	12	e	724.7	82.2	d	2213.9	158.5	b	14.1	1.6	b
Cluster 7	19	37.3	25.3	e	94.6	14.2	b	1045.2	83.8	b	1659	294.3	cd	11.6	1.6	c
Cluster 8	9	149.6	10.7	a	81	5.2	c	658.8	46.8	de	637.6	107.3	f	7.6	0.9	f
r²		0.89			0.76			0.81			0.86			0.77		
F (p-values)		266.2 (< 0.0001)			108.6 (< 0.0001)			138.9 (< 0.0001)			204.7 (< 0.0001)			110.3 (< 0.0001)		
RMSE		12.34			10.99			88.27			191.93			1.30		

Annex 4: Results of the analyse of variance applied to the two variables used to obtain the 5 elevation clusters in EU25 + Norway

Clusters	(n)	Elevation (m)			Elevation dispersion index		
Cluster 1	39	453.47	160.51	c	410.8	174.18	a
Cluster 2	95	81.01	44.85	e	24.41	22.57	e
Cluster 3	7	1494.93	317.61	a	269.31	53.82	b
Cluster 4	63	296.33	93.99	d	70.58	47.61	d
Cluster 5	39	630.17	159.08	b	172.48	74.51	c
r²		0.86			0.74		
F (p-values)		354.6 (<0.0001)			173 (<0.0001)		
RMSE		117.44			81.21		

Annex 5: Results of the analyse of variance applied to the number of livestock per livestock sector for each one of the 10 animals assemblage clusters

Clusters	(n)	BOMILK (%)			BOMEAT (%)			SHGOAT (%)			PORCIN (%)			LAHENS (%)			POUFAT (%)			Clusters' denominations
Cluster 1	1	0.12	-	def	0.42	-	ef	**85.85**	-	d	6.50	-	cde	4.95	-	bcd	2.16	-	abcde	**OVINE**
Cluster 2	7	5.22	6.07	ef	12.38	6.57	ef	**20.82**	5.51	de	**45.08**	20.73	a	7.68	5.11	b	**8.82**	5.70	abcde	**GRANIVORES / OVINE**
Cluster 3	21	12.62	9.10	de	33.87	14.02	c	**37.13**	13.33	a	11.20	9.33	d	2.73	2.45	cd	2.45	2.43	de	**OVINE / BOVINE**
Cluster 4	13	24.65	7.88	bc	**43.75**	11.17	b	**17.16**	6.82	b	7.16	3.08	de	3.42	2.07	cd	3.85	2.05	cd	**BOVINE / OVINE**
Cluster 5	46	**36.15**	11.22	a	**39.20**	10.90	b	1.86	1.51	c	16.64	7.85	c	3.30	2.11	c	2.85	2.13	de	**BOVINE**
Cluster 6	22	**35.02**	15.25	a	**51.05**	16.31	a	7.03	6.58	e	5.16	3.27	e	0.82	1.07	d	0.92	1.16	e	**GRAZING**
Cluster 7	47	27.65	8.32	b	24.46	7.27	d	1.47	1.50	f	32.95	7.91	b	7.72	4.63	b	5.75	3.01	bc	**MIXED without SHGOAT**
Cluster 8	40	16.28	4.63	d	14.86	5.28	ef	1.82	2.09	g	**50.08**	10.79	a	**9.28**	5.31	b	**7.69**	4.09	a	**GRANIVORES**
Cluster 9	8	2.61	2.50	f	6.69	3.37	f	**59.67**	16.31	g	8.34	3.56	de	**14.93**	10.60	a	**7.76**	5.93	ab	**OVIN / POULTRY**
Cluster 10	38	21.84	9.19	c	29.85	8.72	c	14.30	6.01	g	16.90	8.51	c	**9.37**	4.32	b	**7.74**	5.28	a	**POULTRY**
r²		0.52			0.60			0.86			0.76			0.41			0.34			
F (p-values)		28.07 (<0.001)			38.68 (<0.001)			154.26 (<0.001)			81.84 (<0.001)			18.06 (<0.001)			13.19 (<0.001)			
RMSE		9.35			9.94			6.14			8.69			4.20			3.55			

Dark and grey cells indicate averaged values for one cluster higher than the 75th and the 50th percentile respectively; they highlight the livestock sectors those are participating very highly and highly to each one of the 10 animals assemblage retained (i.e. clusters).

Annex 6: Results of the analyse of variance applied to the share of livestock farm types as provided by Eurostat for the 10 animals assemblages clusters identified (To be continued)

Clusters	Clusters	(n)	Cattle dairy (T41) (%)			Cattle fattening (T42) (%)			Cattle dairy + fattening (T43) (%)			Sheep & goat + grazing (T44) (%)			Granivores (T50) (%)		
1	OVINE	1	-	-	-	-	-	-	-	-	-	36.44	-	abcde	2.69	-	bcd
2	GRANIVORES / OVINE	7	3.30	3.30	de	6.17	5.29	bcd	0.23	0.37	c	34.45	12.90	abc	19.54	13.21	a
3	OVINE / BOVINE	21	8.64	9.86	cde	10.63	8.66	bc	1.07	0.80	c	43.42	14.83	a	5.89	5.51	cd
4	BOVINE / OVINE	13	23.80	15.77	ab	19.32	18.74	a	1.47	0.75	bc	35.96	12.65	ab	2.34	1.66	cd
5	BOVINE	46	29.94	14.90	a	11.70	8.67	b	4.45	4.31	a	20.54	12.03	d	4.14	7.49	cd
6	GRAZING	22	27.40	12.28	ab	21.52	16.13	a	4.63	5.17	a	30.40	17.14	bc	2.36	1.98	d
7	MIXED without SHGOAT	47	24.22	13.90	b	9.10	6.86	bc	3.37	4.32	ab	21.25	11.61	d	6.48	3.29	c
8	GRANIVORES	40	14.65	13.27	c	6.04	6.85	cd	2.26	2.19	bc	12.42	13.02	e	19.31	11.41	a
9	OVINE / POURLTRY	8	1.85	3.95	e	0.98	0.47	d	0.71	1.07	c	44.89	9.48	a	3.76	2.37	cd
10	POULTRY	38	12.40	12.59	cd	8.17	9.95	bcd	0.92	1.16	c	25.96	16.07	cd	9.86	8.34	b
r²			0.30			0.20			0.17			0.33			0.40		
F (p-values)			12.55 (<0.0001)			7.39 (<0.0001)			5.82 (<0.0001)			12.75 (<0.0001)			17.29 (<0.0001)		
RMSE			13.09			9.81			3.29			13.58			7.32		

Clusters	Clusters	(n)	Mixed grazing (T71) (%)			Mixed granivores (T72) (%)			Crops + grazing (T81) (%)			Crops + livestock (T82) (%)		
1	OVINE	1	7.21	-	abcd	2.50	-	ab	0.29		bc	50.87	-	a
2	GRANIVORES / OVINE	7	5.06	4.82	abcd	3.21	2.38	b	7.55	5.49	c	20.53	13.20	c
3	OVINE / BOVINE	21	4.91	4.91	abcd	2.36	2.17	b	11.74	8.79	c	11.81	9.56	de
4	BOVINE / OVINE	13	2.45	2.90	cd	1.89	1.77	b	6.10	4.62	c	6.68	7.20	ef
5	BOVINE	46	5.62	8.78	abc	1.98	2.13	b	16.39	10.32	ab	5.34	4.33	f
6	GRAZING	22	2.16	2.42	d	1.66	1.15	b	6.96	6.65	c	3.13	3.40	f
7	MIXED without SHGOAT	47	5.58	6.02	abc	4.26	4.13	b	16.86	9.71	a	9.07	7.65	e
8	GRANIVORES	40	4.91	4.13	bcd	11.60	9.93	a	9.96	6.88	c	18.91	12.23	c
9	OVINE / POURLTRY	8	8.91	3.65	ab	2.53	1.56	b	6.65	4.74	c	29.71	13.15	b
10	POULTRY	38	7.96	6.48	a	11.32	12.56	a	10.15	6.61	c	13.26	8.97	d
r^2			0.08			0.28			0.20			0.39		
F (p-values)			2.23 (0.021)			10.07 (<0.0001)			6.3 (<0.0001)			16.4 (<0.0001)		
RMSE			5.97			6.83			8.20			8.61		

Dark and grey cells indicate averaged values of the farm type share higher than the 75th and the 50th percentile respectively; they highlight the farm types those are participating very highly and highly to each one of the 10 animals assemblages retained (i.e. clusters).

Annex 7: Results of the analyse of variance applied to the share of utilized arable area per crop categories used for cropping systems classification

Clusters	Clusters	(n)	Wheat (%)			Barley (%)			Fodder grasses (%)			Fodder maize (%)		
1	Cereals + other fodders	17	8.23	9.81	cd	22.84	8.03	a	7.26	5.76	g	0.22	0.78	c
2	Fodders Grass > Maize	25	5.52	3.56	d	3.02	2.70	d	62.77	6.26	b	3.06	4.66	b
3	Permanent + Vegetables	23	7.57	8.25	cd	1.78	2.29	d	22.90	11.97	e	0.89	1.78	c
4	Fodder Grass = Maize	36	7.33	4.34	cd	5.54	5.16	c	40.57	7.39	c	3.08	3.54	b
5	Fodder Maize > Grass	32	9.71	5.93	c	3.38	3.13	cd	19.47	5.97	e	6.72	7.38	a
6	Annual + rich protein	48	23.02	5.98	a	9.90	4.69	b	14.10	4.39	f	2.31	1.96	bc
7	Fodder Grass	16	0.56	0.61	e	1.22	1.64	d	86.26	6.55	a	1.54	2.45	bc
8	Annual + Fodder maize	46	16.22	5.25	b	10.66	5.23	b	30.78	7.49	d	2.85	2.83	b
r²			0.59			0.60			0.90			0.18		
F (p-values)			47.93 (<0.0001)			50.39 (<0.0001)			304.41 (<0.0001)			7.3 (<0.0001)		
RMSE			5.84			4.55			7.06			3.78		

Clusters	Clusters	(n)	Rich protein (%)			Pulses (%)			Set-aside & fallow lands (%)			Vegetable and permanent crops (%)		
1	Cereals + other fodders	17	1.66	1.85	c	0.18	0.32	d	3.16	3.68	cd	2.20	4.10	c
2	Fodders Grass > Maize	25	0.98	1.19	c	0.33	0.29	cd	3.17	2.35	cd	5.59	5.80	bc
3	Permanent + Vegetables	23	0.52	1.38	c	0.80	0.56	bc	8.48	5.78	a	34.53	10.83	a
4	Fodder Grass = Maize	36	1.72	1.86	c	0.54	0.66	cd	4.99	3.86	bc	4.94	5.02	bc
5	Fodder Maize > Grass	32	1.22	2.13	c	0.33	0.60	d	4.09	2.97	c	6.24	5.32	b
6	Annual + rich protein	48	6.68	4.40	a	1.27	1.26	a	6.30	3.30	b	3.79	3.59	bc
7	Fodder Grass	16	0.26	0.61	c	0.13	0.17	d	0.88	0.96	d	2.57	2.45	c
8	Annual + Fodder maize	46	4.71	3.05	b	1.04	1.04	ab	8.77	5.81	a	4.01	4.65	bc
r²			0.44			0.20			0.26			0.73		
F (p-values)			25.96 (<0.0001)			8.34 (<0.0001)			11.71 (<0.0001)			91.2 (<0.0001)		
RMSE			2.71			0.83			4.09			5.49		

Dark and grey cells indicate averaged values of the farm type share higher than the 75^{th} and the 50^{th} percentile respectively; they highlight the crop categories those are participating very highly and highly to each one of the 8 cropping systems retained (i.e. clusters).

Annex 8: Results of the analyse of variance applied to the nine variables used for the classification of BOMILK production systems

Clusters	Clusters	(n)	Herd size (LU)			Intensification (€/LU)			Intensification (%)			Stocking density (LU/ha)			Revenues fodders (%)		
1	**Mediterranean intensive BOMILK**	**4**	10897.50	10463.88	b	1150.19	375.40	ab	79.86	3.30	a	3.66	0.29	a	2.11	2.24	cd
2	**Grazing BOMILK complement**	**65**	62528.31	56042.29	b	957.67	244.82	b	74.68	8.01	a	0.80	0.45	de	11.79	8.05	c
3	**Climate constrained BOMILK**	**32**	51202.50	39197.50	b	1405.47	671.84	a	72.49	9.75	a	0.93	0.37	d	45.25	21.74	a
4	**Extensive grass BOMILK**	**13**	259160.00	226488.18	a	446.50	143.64	d	44.83	12.59	c	0.80	0.27	de	20.29	20.62	b
5	**Intensive grass+maize BOMILK**	**60**	222292.83	163726.59	a	882.58	190.22	b	73.89	8.85	a	1.35	0.39	c	17.07	10.59	b
6	**Free-ranging subsistence BOMILK**	**56**	42881.25	44180.61	b	695.81	264.13	c	75.60	6.51	a	0.67	0.23	e	5.22	3.41	d
7	**Intensive maize BOMILK**	**13**	103524.62	83284.30	b	654.84	155.19	cd	59.03	6.21	b	2.33	0.28	b	13.74	11.09	bc
r²			0.38			0.37			0.45			0.68			0.53		
RMSE			105699.78			323.90			8.34			0.36			11.76		
F (p-value)			23.78 (<0.0001)			22.95 (<0.0001)			32.23 (<0.0001)			84.78 (<0.0001)			43.57 (<0.0001)		

Clusters	Clusters	(n)	Revenues BOMILK (%)			Energy autonomy (%)			Fodder grass area (%)			Fodder maize area (%)		
1	**Mediterranean intensive BOMILK**	**4**	13.89	9.46	c	21.48	18.86	e	12.77	21.58	cd	0.55	0.73	cd
2	**Grazing BOMILK complement**	**65**	29.89	11.17	b	96.72	16.70	b	24.67	19.51	d	2.07	1.95	c
3	**Climate constrained BOMILK**	**32**	51.53	11.23	a	66.44	23.81	d	45.56	33.09	b	0.70	1.57	d
4	**Extensive grass BOMILK**	**13**	29.66	12.15	b	137.25	4.70	a	60.52	23.12	a	0.75	0.78	cd
5	**Intensive grass+maize BOMILK**	**60**	46.80	13.68	a	83.29	16.26	c	32.98	16.35	c	5.18	3.45	b
6	**Free-ranging subsistence BOMILK**	**56**	16.65	12.27	c	60.00	13.47	d	27.24	13.91	cd	0.52	0.59	d
7	**Intensive maize BOMILK**	**13**	29.05	10.92	b	85.77	6.15	c	28.64	14.46	cd	14.15	6.33	a
r²			0.53			0.62			0.19			0.63		
RMSE			12.12			16.31			20.06			2.55		
F (p-value)			45.07 (<0.0001)			64.8 (<0.0001)			9.48 (<0.0001)			65.61 (<0.0001)		

Annex 9: Results of the analyse of variance applied to the eight variables used to classify the BOMEAT production systems

Clusters	Clusters	(n)	Intensification (€/LU)			Stocking density (LU/ha)			Fodders revenue (% of total)			BOMEAT revenue (M€)		
1	Complement ovine BOMEAT	78	680.65	184.62	b	0.79	0.39	c	17.92	13.13	b	124.0	101.4	bc
2	Intensive grass maize BOMEAT	23	542.25	210.25	c	1.11	0.35	b	19.03	15.45	bc	992.6	424.4	a
3	Complement porcine BOMEAT	21	280.99	101.47	d	0.58	0.20	d	5.73	4.14	d	118.6	142.4	bc
4	Intensive maize BOMEAT	55	513.14	112.48	c	1.80	0.60	a	13.84	10.58	c	179.0	144.43	b
5	Subsidiary Nordic BOMEAT	14	790.39	95.69	a	0.93	0.23	bc	62.29	12.73	a	61.6	53.0	c
6	Subsidiary Mediterranean BOMEAT	43	515.49	135.58	c	0.77	0.29	cd	5.17	3.24	d	75.6	77.8	c
r²			0.408			0.535			0.581			0.708		
RMSE			153.574			0.410			10.973			169.8		
F (p-values)			31.47 (<0.0001)			52.46 (<0.0001)			63.11 (<0.0001)			110.78 (<0.0001)		

Clusters	Clusters	(n)	Energy autonomy (%)			BOMEAT herd size (% of total)			Fodder grass (%UAAtot)			Fodder maize (%UAAtot)		
1	Complement ovine BOMEAT	78	77.60	22.49	d	33.85	12.44	b	40.63	26.33	a	1.23	1.66	c
2	Intensive grass maizeBOMEAT	23	96.37	27.74	b	47.49	17.19	a	40.92	22.78	a	3.91	4.46	b
3	Complement porcine BOMEAT	21	113.01	18.45	a	22.02	12.97	d	24.78	15.34	b	2.90	2.03	b
4	Intensive maize BOMEAT	55	86.24	17.11	c	28.81	13.68	c	28.12	15.96	b	7.36	5.48	a
5	Subsidiary Nordic BOMEAT	14	75.19	25.03	cd	38.21	6.69	b	21.70	16.48	b	0.04	0.06	c
6	Subsidiary Mediterranean BOMEAT	43	59.15	10.96	e	14.04	6.50	e	21.87	9.33	b	0.79	0.91	c
r²			0.355			0.385			0.146			0.408		
RMSE			20.053			12.256			19.919			3.237		
F (p-values)			25.05 (<0.0001)			28.57 (<0.0001)			7.79 (<0.0001)			31.36 (<0.0001)		

Annex 10: Results of the analyse of variance applied to the eight variables used to classify the SHGOAT production systems

Clusters	Clusters	(n)	Stocking density (LU/ha)			Energy autonomy (%)			Fodder grass (%of total UAA)			Intensification (%)		
1	Complement to dairy cattle Nordic SHGOAT	11	0.899	0.227	c	78.294	24.741	b	16.01	12.768	e	79.394	3.401	a
2	Mediterranean free-ranging SHGOAT	19	0.79	0.302	c	55.721	19.167	c	32.746	16.122	c	77.479	2.609	ab
3	Temperate intensive indoor SHGOAT	22	1.413	0.694	b	107.337	28.741	a	46.194	25.683	b	39.465	7.981	d
4	Complement to granivores intensive SHGOAT	101	0.69	0.302	c	82.121	22.105	b	23.853	14.592	de	73.466	10.983	bc
5	Complement to bovine intensive SHGOAT	65	1.669	0.688	a	80.729	22.69	b	27.837	15.182	cd	73.511	7.292	bc
6	Complement to bovine mountainous SHGOAT	21	0.87	0.402	c	82.684	33.616	b	74.071	15.679	a	71.461	10.339	c
r²			0.439			0.17			0.461			0.561		
RMSE			0.486			24.026			16.196			9.073		
F (p-values)			36.525 (<0.0001)			9.53 (<0.0001)			39.829 (<0.0001)			59.443 (<0.0001)		

Clusters	Clusters	(n)	SHGOAT revenues (M€)			Herd size (% of LU tot)			Fodders revenues (%)		
1	Complement to dairy cattle Nordic SHGOAT	11	7.3	4.8	c	17.977	11.600	b	64.171	13.627	a
2	Mediterranean free-ranging SHGOAT	19	252.1	195.5	a	50.546	20.240	a	6.157	4.865	d
3	Temperate intensive indoor SHGOAT	22	81.5	117.8	b	9.605	9.410	c	10.549	12.932	d
4	Complement to granivores intensive SHGOAT	101	34.0	45.8	c	9.215	10.231	c	8.79	6.280	d
5	Complement to bovine intensive SHGOAT	65	13.1	22.3	c	3.197	7.557	d	17.937	11.407	c
6	Complement to bovine mountainous SHGOAT	21	38.8	53.9	bc	6.145	6.490	cd	33.936	18.309	b
r²			0.422			0.579			0.619		
RMSE			74.096			10.47			10.311		
F (p-values)			34.049 (<0.0001)			63.972 (<0.0001)			75.757 (<0.0001)		

Annex 11: Results of the analyse of variance applied to the seven variables used to classify the PORCIN production systems

Clusters	Clusters	(n)	Intensification (€/LU)			Intensification (%)			Lysine auto-sufficiency (%)			Total lysine requirement (ton/year)		
1	**Subsidiary traditional PORCIN**	**24**	393.63	36.87	d	50.99	2.92	e	30.81	23.65	bc	792.36	491.63	de
2	Primary intensive with bovine PORCIN	**11**	694.23	78.87	bc	69.56	5.94	c	0.72	0.82	c	5416.23	4272.36	b
3	Subsidiary intensive with crops PORCIN	**7**	674.77	37.53	bc	69.37	7.25	c	466.86	181.97	a	372.45	232.59	de
4	Common secondary intensive PORCIN	**114**	648.21	103.6	c	72.98	4.96	b	37.29	53.24	b	1630.61	1778.71	cd
5	Secondary very intensive PORCIN	**29**	865.91	43.94	a	80.09	2.12	a	18.46	14.97	bc	2351.29	3254.77	c
6	Subsidiary complement to grazing PORCIN	**55**	709.74	95.42	b	59.84	4.57	d	11.23	18.41	c	403.68	603.14	e
7	Specialized PORCIN	**3**	687.43	39.15	bc	71.97	3.21	bc	3.9	3.73	bc	22969.49	7181.97	a
r²			0.62			0.78			0.71			0.63		
RMSE			88.863			4.56			48.56			2022.46		
F (p-values)			65.25 (<0.0001)			141.74 (<0.0001)			95.99 (<0.0001)			67.06 (<0.0001)		

Clusters	Clusters	(n)	Carcass yield (kg/head)			Stocking density (LU/ha rich prot)			Herd size (% herd total)		
1	**Subsidiary traditional PORCIN**	**24**	84	4.47	c	2.21	2.33	c	18.08	6.87	cd
2	Primary intensive with bovine PORCIN	**11**	87.41	6.12	bc	68.22	30.49	a	52.68	15.84	a
3	Subsidiary intensive with crops PORCIN	**7**	83.53	6.78	c	0.36	0.26	c	8.29	3.88	d
4	Common secondary intensive PORCIN	**114**	89.5	7.36	b	4.35	5.07	c	27.22	16.54	b
5	Secondary very intensive PORCIN	**29**	115.64	6.36	a	5.75	9.65	c	25.46	20.18	bc
6	Subsidiary complement to grazing PORCIN	**55**	72.05	8.82	d	6.38	9.27	c	13.08	9.83	d
7	Specialized PORCIN	**3**	85.97	11.53	bc	27.01	14.34	b	52.42	10.94	a
r²			0.74			0.69			0.30		
RMSE			7.37			9.20			14.77		
F (p-values)			113.29 (<0.0001)			86.58 (<0.0001)			16.69 (<0.0001)		

Annex 12: Results of the analyse of variance applied to the seven variables used to classify the LAHENS production systems

Clusters	Clusters	(n)	Intensification (€/LU)			Intensification (%)			Revenue (M€)			Lysine autosufficiency (%)		
1	**Primary economically constrained LAHENS**	**45**	445.10	105.17	b	90.09	7.74	b	41.36	33.65	b	24.31	23.14	b
2	**Subsidiary Common intensive LAHENS**	**106**	766.27	122.64	a	92.71	3.31	a	23.16	24.75	b	23.68	26.82	b
3	**Primary very dependent LAHENS**	**57**	759.26	86.15	a	87.95	8.26	b	94.76	114.45	a	13.13	14.89	b
4	**Subsidiary climatically constrained LAHENS**	**8**	494.38	3.78	b	58.97	4.66	c	17.98	19.39	b	16.58	13.38	b
5	**Subsidiary complement to crops LAHENS**	**12**	794.31	3.99	a	94.97	0.37	a	20.36	20.44	b	320.08	205.39	a
r²			0.62			0.54			0.19			0.64		
RMSE			105.5			5.90			61.91			50.86		
F (p-values)			90.379 (<0.0001)			64.764 (<0.0001)			13.39 (<0.0001)			98.921 (<0.0001)		

Clusters	Clusters	(n)	Yield (kg/head)			Stocking density (LU/ha)			Herd size (%)		
1	**Primary economically constrained LAHENS**	**45**	9.63	1.45	d	0.25	0.33	b	9.15	4.47	b
2	**Subsidiary Common intensive LAHENS**	**106**	16.37	1.91	b	0.25	0.38	b	3.63	2.29	c
3	**Primary very dependent LAHENS**	**57**	14.69	1.92	c	2.11	4.03	a	11.78	5.69	a
4	**Subsidiary climatically constrained LAHENS**	**8**	19.24	0.46	a	0.07	0.05	b	3.84	2.43	c
5	**Subsidiary complement to crops LAHENS**	**12**	16.57	2.36	b	0.07	0.14	b	3.49	3.50	c
r²			0.69			0.14			0.46		
RMSE			1.83			2.04			3.91		
F (p-values)			124.328 (<0.0001)			9.14 (<0.0001)			47.741 (<0.0001)		

Annex 13: Results of the analyse of variance applied to the seven variables used to classify the POUFAT production systems

Clusters	Clusters	(n)	Intensification (€/LU)			Intensification (%)			Revenues (M€)			Lysine autosufficiency (%)		
1		83	1254.79	256.48	d	67.17	6.95	c	30.55	28.56	b	28.4	26.79	b
2		46	1502.77	157.72	c	83.01	2.69	a	33.79	33.64	b	14.17	22.35	b
3		1	1351.8		bcd	85.28		ab	97.37		ab	0.16		b
4		11	1690.79	5.19	b	85.69	0.28	a	63.88	58.65	b	326	214.34	a
5		30	1498.41	114.22	c	74.54	10.41	b	303.76	273.38	a	18.31	12.1	b
6		48	1560.19	244.71	bc	74.5	7.75	b	42.97	54.48	b	24.65	39.96	b
7		12	2397.49	118.32	a	78.43	0.86	b	58.12	57.42	b	1.24	1	b
r²			0.61			0.48			0.43			0.61		
RMSE			209.81			6.77			105.55			52.61		
F (p-values)			57.394 (<0.0001)			34.385 (<0.0001)			27.906 (<0.0001)			59.195 (<0.0001)		

Clusters	Clusters	(n)	Yield (kg/head)			Herd size (%)			Stocking density (LU/ha)		
1		83	1.78	0.17	c	3.74	2.9	d	0.15	0.27	d
2		46	2.08	0.33	ab	4.34	3.33	cd	0.86	1.86	c
3		1	1.93		abc	16.93		a	26.48		a
4		11	2.18	0.01	a	4.67	5.11	bcd	0.1	0.19	d
5		30	2	0.14	b	11.13	4.07	a	0.52	0.73	cd
6		48	1.2	0.2	d	5.25	3.56	bc	0.22	0.35	d
7		12	1.7	0	c	7.19	3.46	b	2.33	2.03	b
r²			0.71			0.35			0.76		
RMSE			0.21			3.45			1.01		
F (p-values)			89.311 (<0.0001)			20.243 (<0.0001)			119.951 (<0.0001)		

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Abstract
According to the Administrative Arrangement (AA) No. AGRI-2008-02451 signed between DG AGRI and DG JRC in 2008, the final expectation of the GGELS project is a more precise quantification of the greenhouse gases emission (GHG) from livestock production in Europe by considering GHG emission all along the production chains. To later analyse and plan European GHG mitigation scenario for the livestock sectors, a particular effort of description of the Livestock Production Systems (LPS) in place in Europe is necessary, livestock production differing largely over Europe. Total GHG emission from livestock production being the sum of GHG emissions specific to each step of the production chain, it was crucial to consider each production step for which GHG emissions is differing according to the local farming particularities and to the specific practices in vigour.

The previous statements asked for considering spatial as well as strategic diversity of LPS existing in Europe and for the classification of LPS. For that, Work Package 2 (WP2) of the GGELS project has to focus on the conceptualisation and build up of a new LPS typology allowing policy makers to precisely identify LPS diversity. Regarding the main scales at which LPS datasets are available to date, LPS typology is planed to be performed at NUTS2 level (region level) in EU27. The dimensions to be considered in the LPS typology must reflect the strategies decided by the breeders according to market and regional (mainly biotic) constraints met in regions; these dimensions have also to point out the major livestock production steps responsible for GHG emission variation between regions. Finally, in respect to the administrative arrangement, LPS had to be considered for six different reared species: bovine for milk production (BOMILK), bovine for meat production (BOMEAT), porcine production of meat (PORCIN), ovine production of milk and meat (SHGOAT), meat from poultry production (POUFAT) and eggs production (LAHENS). The different LPS dimensions retained to differentiate European regions concerned *"the herd's assemblage"*, *"the animal feeding strategy"*, *"the animal keeping strategy"* and again the *"manures' management practices"* which condition GHG from livestock productions. Concerning manures management practices, since no specific information existed at region level, while JRC expertise on this issue was insufficient, it has been decided to launch a call for tender to select academic parties for a specific study on this issue following a questionnaire approach. The results of this survey should improve NUTS2 LPS description with manure management information for each region and improve efficiency of the final LPS typology to be produced.

However, the setting up of a survey addressing manures' management practices in vigour over Europe cannot be undertaken without considering the other dimensions cited above. To facilitate this task, DG JRC decided to perform a preliminary classification of the NUTS2 zones according to the remaining dimensions plus other regional descriptors such as regional meteorological particularities, economic intensity of the LPS, stocking density or again the potential autonomy to feed reared animals from local crops production. For that, official statistics contained inside databases of the CAPRI (Common Agricultural Policy Regional Impact Analysis) Modelling System have been used to describe diversity and particularities of the LPS (by specie) in every one of the European regions. Independently, by using Crop Growth Monitoring System (CGMS) datasets, classification of the climatic conditions met in Europe have been mapped. All classifications were performed using multivariate statistical procedures such as Principal Components Analysis (PCA) and two-way Hierarchical Ascendant Classification (HAC). Results of the by-specie LPS classifications have been then confronted to the clusters describing climate conditions in regions to interpret LPS diversity. In parallel, other statistics such as regional farm types repartition provided by Eurostat were used to verify of the pertinence of the results obtained from the purely statistical method applied. Then, clusters verified were interpreted by relating all dimensions together to give a picture as reliable as possible of the reality following a more subjective approach; finally, to ease the comprehension of the reader, by-specie LPS clusters were mapped in a GIS environment.

In most cases and especially for grazing animals (BOMILK, BOMEAT, SHGOAT), the clusters obtained statistically were relatively reliable to the current state of the art. The dimensions retained allowed us to identify and characterize the main regions where bovine and porcine livestock production are performed. The interpretation of the clusters when passing from a purely quantitative (statistical) to a qualitative interpretation (more subjective) was relatively obvious and didn't pose difficulties. On the other hand, interpretation of the clusters obtained for POUFAT and LAHENS (and for PORCIN at the less extent) was sometime uneasy; despite specific adaptations of certain descriptors, certain clusters were difficult to distinguish or to interpret. Local feedstuffs autonomy and stocking density for instance were not as informative for monogastric animals as they were for grazing animals. Concerning grazing animals, the lack of information in the European database and in the CAPRI datasets influenced greatly the keeping strategies identified and attributed to the clusters; further studies should consider in deep this dimension regarding the importance it has with the manure management and feeding strategies and the nature of the GHG emitted.
Despite possible improvements, the preliminary zoning performed here allowed us to identify and describe reliably the specificities of the LPS in every one of the European regions (EU27). From this, we proposed a by-specie and by-LPS type sampling of the regions. This was undertaken to help the academic party to decide later of the minimum sample size necessary to obtain reliable information on the regional manures' management practices in vigour regarding the particularities of the LPS pointed out in this report.

Keywords
Livestock production systems, GHG, bovine, ovine, porcine, poultry, Europe, classification, zoning, manures management, feeding, keeping, intensification, revenues, CAPRI

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